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Publication Office: 20th & Northampton Sts., Easton, Pa.
Editorial, Executive and Advertising Offices: 2525 N. High St., Columbus, Ohio
Entered as second-class matter at the post office at Easton, Pa., under the act of March 3, 1879. Published twice monthly.
Subscription fifteen dollars ($15.00) a year. Single numbers $1.50
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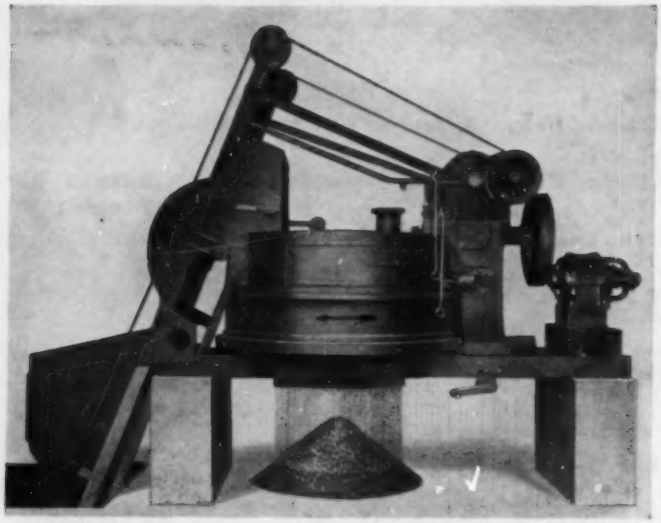

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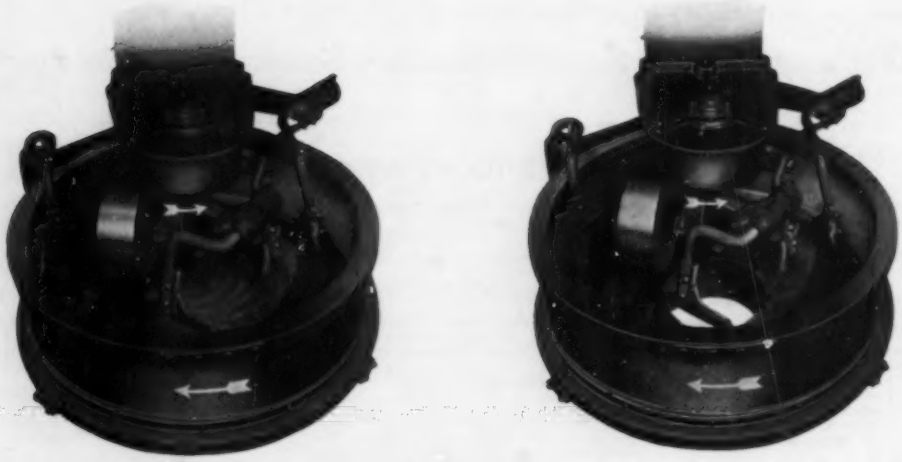

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OF

THE AMERICAN CERAMIC SOCIETY

Volume 21 | January, 1942 | Number 1

CERAMIC HISTORY

HERMAN MUELLER

A Charter Member of The American Ceramic Society

Herman Mueller left public school at the age of fourteen and was sent to Nuernberg to the School of Industrial Arts, where he remained for two years; he then attended the Academy of Fine Arts in Munich for a year and a half.

While in Munich, he contracted typhoid fever and was seriously ill for a long time. Upon his recovery, the doctor advised him to return to his home in Rodach and to walk as much a day as possible and rest between times.

He decided to take the doctor's advice and go home. When he left Munich, however, he made a slight detour and walked to Strassburg, where he secured employment as a sculptor for a short time. He started out again by foot down the Rhine to Cologne; from there he went to Bremen, Kiel, and Hamburg. In Hamburg, he secured work to his liking with a sculptor and remained there for some time.

Mr. Mueller standing in the nearly completed pool at the Hotel Chamberlin, Old Point Comfort, Va.

After saving a little money, he started walking for home again, but decided on another slight detour which took him to Prague and Vienna. The World's Fair was being held in Vienna and he wanted to see it, so he stayed in Vienna for a while. He admired and often talked about the beautiful blue Danube which flows by Vienna. He later obtained passage on a barge which took him to Budapest, Hungary; he carved a figurehead for the barge for his fare. In Budapest, he could not find any work, so he decided to resume his walking toward home. He walked from Budapest to Saltzburg, where he found work with a fine sculptor. Here he remained until he was called home for military duty at the age of twenty-one. After serving two years in the Army in Coburg, he was discharged with the rank of corporal. After working for a short time in Coburg, he decided to come to America.

On arriving in America in 1875, he went to Cincinnati and started making tombstones and sidewalks of cement, a material about which very little was then known. He then left this business to accept a position as a modeler in a terra-cotta factory in Indianapolis, Indiana. Some time later he accepted a contract to sculpture some statues for the four faces of the Indiana State House. The statues, depicting various historical periods, were to be cut in sandstone on a scale slightly larger than twice life size.

While carrying out this assignment, Mr. Mueller received an offer in 1886 to become associated with the American Encaustic Tiling Company, Zanesville, Ohio, and help build a new factory for them. He remained with this Company until 1893, when he and Karl Langenbeck started the Mosaic Tile Company, Zanesville, Ohio. Here he stayed until 1903. (Mr. Langenbeck was also a Charter Member of The American Ceramic Society. His photo appeared on the cover of the October, 1938, *Bulletin* shortly after his death in September, 1938.)

About 1897, Mr. Mueller was awarded the John Scott Medal by the Franklin Institute in Philadelphia for his industrial contributions to the United States and particularly to the tiling industry.

In 1903, he went to Morrisville, Pennsylvania, where he accepted a position as superintendent for the Robertson Art Tile Company. Here he established the manufacture of ceramic mosaic (the Company had previously confined its product to glazed wall tile).

T. R. Cheyney, treasurer of the Robertson Art Tile Company, makes the following comments concerning Mr. Mueller in a letter dated October 30, 1941:

"Mr. Mueller was a 'super' tile salesman. He brought to the attention of our Company his ideas for applying ceramic mosaic to the veneering of swimming pools, surrounding walks, and wainscots. The product was an immediate success and, with the aid of Mr. Mueller, the first installation was made in the Hotel Chamberlin, Old Point Comfort, Virginia, which burned several years ago. Mr. Mueller not only conceived the idea but personally designed the treatment and supervised the work through a tile contractor."

In 1908, Mr. Mueller started his own business, the Mueller Mosaic Tile Company, in Trenton, New Jersey. He remained as president of this Company until he died, at the age of eighty-seven, on September 21, 1941.

Diverse Interests

Mr. Mueller was always a great lover of music and was generously gifted with a rich bass-baritone voice. He sang in many concerts and in operas in Indianapolis, Cincinnati, St. Louis, and Milwaukee, and was well known in

musical circles both in America and in Germany. Victor Herbert and Robert Thallon were among the friends who frequently visited him. Although he sang with professional artists, he sang as an amateur and for his own pleasure. He delighted particularly in singing roles in such Gilbert and Sullivan operas as "The Mikado" and "H.M.S. Pinafore."

One of his greatest and life-long interests lay in the field of education. He served as president of the Trenton Board of Education for many years and was the instigator of the junior high school system of education, which enables students who plan a vocational rather than an academic future to become acquainted with the rudiments of the various crafts and practical arts.

In January, 1910, the Governor of New Jersey appointed Mr. Mueller a member of the board of trustees of the School of Industrial Arts of the City of Trenton. He was elected president of this school in April, 1929.

Article from *Flooring*

The following article, which appeared in the October, 1941, issue of *Flooring*, gives added insight into the character and personality of Mr. Mueller.

Trained in his youth as a sculptor, Mr. Mueller's approach to the manufacture and installation of tile was consistently that of the artist. He looked on tile primarily as an artistic medium, though his views were usually tempered by practical considerations and were never marked by an uncompromising attitude toward the final emergence of most tile as a mass-production, machine-made product.

Possessing, in addition to his creative talents, the ability to impress architects and building owners with the virtues of tile, Mr. Mueller is today credited with having pioneered many of the major uses of this material. According to a number of tile men who have studied the development of their industry, it was his convincing personality and salesmanship that led to the first swimming-pool tile installation in this country.

This installation, marking a departure from the previously general use of concrete on pool bottoms and sides, was made in the Hotel Chamberlin at Old Point Comfort, Virginia, a fashionable rendezvous of old Southern families during the "Gay Nineties."

It is generally agreed that Mr. Mueller was also the first to suggest, at least with sufficient authority to see the widespread adoption of the idea by architects and builders, the use of tile as an enriching, embellishing material for the plain brick or stucco fronts of buildings. One of the first façades to be so decorated was that of the Hotel Stratford in Bridgeport, Connecticut.

Although his artistic influence and forceful personality will probably be missed in all sections of the tile industry, their absence will likely be felt with especial keenness at national conventions of the Tile Contractors Association, at which he was a prominent figure for many years. He was often a speaker at these gatherings and, while a certain tendency to reminisce in the "good old days" manner might have been condoned in a man so long in the industry, his talks were always timely and forward-looking.

A revealing demonstration of the youthful spirit that went far toward gaining him the industry's affection was his custom of dancing a waltz at each yearly meeting of the Association. No convention, until the past few years at least, was considered complete until Mr. Mueller had done his annual Terpsichorean turn.

Usually acknowledged the preeminent authority on all matters pertaining to design in his branch of the construction industry, Mr. Mueller was at times called on for expert testimony in the courts, usually bringing out facts from a vast store of knowledge that swung decisions definitely to one side or the other.

On one such occasion, two linoleum manufacturers were engaged in a lawsuit in a Trenton court over the rights of certain designs shown in the catalogue of the defendant.

Mr. Mueller, who was at the time a member of the Trenton Board of Education, was invited by the judge to sit with him on the bench, and later, during the progress of the trial, asked him to take the witness stand. He then inquired of Mr. Mueller which litigant, in his judgment, had the right to exclusive use of the designs in question.

"It seems to me," Mr. Mueller replied, "that they have both copied them from my catalogue. But I don't contemplate any action, because I copied them from the Egyptians!"

At one of his last appearances before a public audience, at a symposium of the New York Society of Ceramic Arts at the Metropolitan Museum in 1939, Mr. Mueller strongly urged that greater emphasis be given to the artistic values of tile within the industry itself and in its dealings with architects and building owners.

"We know," he declared at that time, "that the tile installed sometimes in fine houses is a duplicate of the tile in the washroom of a saloon. Architects may specify what they want, but there are so many who come in to chisel, to tell them, 'This is just as good.' They show them a tile that glitters and say, 'This is nicer than that.' The architect may sometimes protest, but ignorance beats him. The answer is education—teaching people what really constitutes art.

"Ask these people who are so efficient in pumping out a lot of tile whether they are making any money," he went on. "They are breaking up. An artist has an advantage if he has ambition and works constructively. The man who depends on a machine needs money. If the other fellow has more money, he can do more by buying more and better machinery. I am not talking against the machine. I invented some myself. But I don't want to leave art, like Cinderella, sitting in front of the fireplace forever."

N. L. BOWEN RECEIVES PENROSE MEDAL

The Penrose Medal, the most important recognition of merit in the field of geology, has been awarded to Norman L. Bowen, professor of geology, University of Chicago, Chicago, Illinois, "in recognition of his achievements in the application of the principles of physical chemistry to the study of the origin of igneous rocks."

Dr. Bowen, who is fifty-four years old, is the youngest scientist to receive this award. It was presented to him by the Geological Society of America on December 30, 1941, at the annual meeting of that society in Boston, Massachusetts.

Dr. Bowen was graduated from Queen's University at Kingston, Ontario, Canada, and received his Doctor of Philosophy degree from the Massachusetts Institute of Technology. Before becoming associated with the University of Chicago in 1937, he was a field geologist for the Canadian Geological Survey and a member of the staff of the Geophysical Laboratory of the Carnegie Institution of Washington, Washington, D. C.

Although Dr. Bowen is not a ceramist and is not a member of The American Ceramic Society, he has taken a deep interest in The Society and has, through his publications and experiments, contributed greatly to the advancement of ceramics. During the last World War, Dr. Bowen, as a supervisor of optical glass production for the War Industries Board, carried on work that was recognized as of prime military importance. He was also co-discoverer of mullite, a basic constituent of fire-clay refractories.

N. L. Bowen

Publications

During Dr. Bowen's association with the Geophysical Laboratory, he was the author of eighty-five technical papers. The extent to which his work bore on ceramic subjects is shown by the following list of papers on refactories, glass, glazes, water glass, and slags.

(With Olaf Andersen), "Binary System $MgO–SiO_2$," *Amer. Jour. Sci.*, [4], **37**, 487–500 (1914); German translation, "Binäre System Magnesiumoxyd–Silicium–2-oxyd," *Z. anorg. Chem.*, **87**, 283–99 (1914).

"Crystals of Barium Disilicate in Optical Glass," *Jour. Wash. Acad. Sci.*, **8**, 265–68 (1918).

"Identification of 'Stones' in Glass," *Jour. Amer. Ceram. Soc.*, **1**, 594–605 (1918).

"Devitrification of Glass," *ibid.*, **2**, 261–78 (1919).

"Tridymite Crystals in Glass," *Amer. Mineralogist*, **4**, 65–66 (1919).

"Optical Properties of Anthophyllite," *Jour. Wash. Acad. Sci.*, **10**, 411–14 (1920).

"Diffusion in Silicate Melts," *Jour. Geol.*, **29**, 295–317 (1921).

(With G. W. Morey), "Melting of Potash Feldspar," *Amer. Jour. Sci.*, [5], **4**, 1–21 (1922).

(With J. W. Grieg), "System $Al_2O_3–SiO_2$," *Jour. Amer. Ceram. Soc.*, **7**, 238–54 (1924).

(With J. W. Greig and E. G. Zies), "Mullite, a Silicate of Alumina," *Jour. Wash. Acad. Sci.*, **14**, 183–91 (1924).

(With G. W. Morey), "Binary System Sodium Metasilicate–Silica," *Jour. Phys. Chem.*, **28**, 1167–79 (1924).

(With G. W. Morey), "Ternary System Sodium Metasilicate–Calcium Metasilicate–Silica," *Jour. Soc. Glass Tech.*, **9**, 226–64 (1925).

(With R. W. G. Wyckoff and J. W. Greig), "X-Ray Diffraction Patterns of Mullite and Sillimanite," *Amer. Jour. Sci.*, **11**, 459–72 (1926).

(With G. W. Morey), "Decomposition of Glass by Water at High Temperatures and Pressures," *Jour. Soc. Glass Tech.*, **11**, 97–106 (1927).

(With F. C. Kracek and G. W. Morey), "System Potassium Metasilicate–Silica," *Jour. Phys. Chem.*, **33**, 1857–79 (1929).

(With G. W. Morey and F. C. Kracek), "Ternary System $K_2O–CaO–SiO_2$" (with correction), *Jour. Soc. Glass Tech.*, **14**, 149–87 (1930).

(With J. F. Schairer), "System $FeO–SiO_2$," *Amer. Jour. Sci.*, **24**, 177–213 (1932).

"Crystals of Iron-Rich Pyroxene from a Slag," *Jour. Wash. Acad. Sci.*, **23**, 83–87 (1933).

"Vogtite, Isomorphous with Wollastonite," *ibid.*, pp. 87–94.

(With J. F. Schairer and E. Posnjak), "System $Ca_2SiO_4–Fe_2SiO_4$," *Amer. Jour. Sci.*, **25**, 273–97 (1933).

(With J. F. Schairer and E. Posnjak), "System $CaO–FeO–SiO_2$," *ibid.*, **26**, 193–284 (1933).

(With J. F. Schairer), "System $MgO–FeO–SiO_2$," *ibid.*, **29**, 151–217 (1935).

NECROLOGY

C. H. STONE, JR.

Charles H. Stone, Jr., a chemical, ceramic, and mining engineer of Cleveland, Ohio, died suddenly of heart trouble on October 21, 1941, at the age of seventy-one.

In 1894, Mr. Stone received a Bachelor of Science degree in Chemical Engineering from the Case School of Applied Science, Cleveland, Ohio. Following his graduation, he took some work at the Cleveland College of Physicians and Surgeons and at the University of Michigan. In 1895 and 1896, he was assistant to Dr. C. F. Mabery at the Case School and also worked with Dr. A. W. Smith and Dr. P. L. Hobbs, who at that time were state chemists for Ohio.

In 1920–1921, Mr. Stone was research chemist for the Union Carbide Company in Cleveland, Ohio, where he worked on zirconium, titanium, and beryllium. He was later vice-president and general manager of the Romega Clay Products Company of Rome, Georgia; in 1927–1928, he did research work for the Vitrefrax Corporation in Los Angeles, California. From 1928 through 1933, Mr. Stone was associated with the Glascote Company of Cleveland, Ohio, first as research director and then as vice-president in charge of production. Since that time he had been in consulting work and, at the time of his death, he was investigating magnesium and cobalt properties for several corporations.

R. D. Landrum, of the Harshaw Chemical Company, Cleveland, Ohio, speaks of Mr. Stone as follows: "All who knew Charlie were benefited by his cheerful disposition and his keen sense of humor. He was unusual, particularly in his tremendous energy and in his ability to adapt himself to conditions even when they were adverse. Probably his main urge in life was to be helpful to others."

Mr. Stone was a member of The American Ceramic Society from 1921 through 1931.

CHARLES F. GOODWIN*

Charles F. Goodwin, secretary-treasurer of the United States Potters Association, East Liverpool, Ohio, died suddenly of a heart attack on December 11 while attending the annual meeting of the Association in Cleveland, Ohio. He had been suffering from a heart ailment for several months, but had gone to Cleveland in spite of this to make arrangements for the meeting.

Mr. Goodwin was a descendant of one of the pioneer potters of East Liverpool. John Goodwin, his grandfather, received his pottery experience in England and came to the United States in 1842. Two years later, he settled in East Liverpool and worked in the pottery of James Bennett and in the plant of Benjamin Harker.

Upon the death of John Goodwin in 1875, a business which he had established was taken over by his sons, James, George, and Henry Goodwin. The Goodwin Brothers Pottery Company was incorporated in 1893.

Charles F. Goodwin was a son of James Goodwin and was born August 1, 1874, in East Liverpool. While still a young man, Mr. Goodwin and his brother, the late John S. Goodwin, entered the business established by their grandfather. He was active in the pottery until about 1911, when the Company discontinued operations.

Mr. Goodwin was elected secretary-treasurer of the United States Potters Association on June 4, 1912, succeeding John T. Cartwright, who died that year. He had held this office continuously since that time and, while on his deathbed, was re-elected to this office for his thirtieth year.

Because of his many years with the business, perhaps no man was better informed about the problems of ceramic manufacturing than Mr. Goodwin. He was a member of all committees of the United States Potters Association by virtue of his office and was one of the manufacturers' representatives at all wage parleys and conferences since he assumed the office.

Mr. Goodwin also once served on the Board of Education in East Liverpool.

He leaves his widow and two sons.

* Excerpts from *The East Liverpool Review*, December 11, 1941.

Charles F. Goodwin

ACTIVITIES OF THE SOCIETY

NORTHERN CALIFORNIA SECTION

The annual fun festival of the Northern California Section was held on December 8, 1941, at the Coit Hotel, Oakland, Calif. Everyone enjoyed the turkey dinner, the group of impersonations given by Russell Ross, and the hidden talent Al Adcock uncovered from the midst of the regular group of members. The showing of the Fred Waring sound movie, "Tobacco Time," added the finishing touch to an evening of fine entertainment.

—R. OLDEN, *Secretary*

ST. LOUIS SECTION

A dinner meeting of the St. Louis Section was held at Joe Garavelli's Restaurant in St. Louis, Mo., on December 4, 1941. Fifty-seven persons were in attendance.

The following program was presented after dinner:

(1) "Prospecting, Developing, and Mining Semiplastic Fire Clay in Missouri" by R. S. BRADLEY, director of research, A. P. Green Fire Brick Co., Mexico, Mo.

(2) "Use of the Electropode for Analyzing Alkali Content of Ceramic Materials" by W. J. SMOTHERS, graduate assistant in physics, Missouri School of Mines and Metallurgy, Rolla, Mo. A discussion of this paper was presented by Paul G. Herold, head of the Department of Ceramic Engineering, Missouri School of Mines and Metallurgy.

(3) Sound film, "Manufacture of Plate Glass" by the United States Bureau of Mines.

After the showing of the picture, H. H. Hanna, chairman of the Section, read a letter received from R. C. Purdy, General Secretary of The American Ceramic Society.

P. S. Trowbridge, acting for L. C. Hewitt, chairman of the Nominating Committee, submitted a request for the re-election of the present officers. When it was learned, however, that acting vice-chairman L. A. Kimberling was leaving the Section because of a new position with an eastern company, Henry Meyer, St. Louis Steel Castings Co., St. Louis, Mo., was nominated and unanimously elected vice-chairman in his place.

—J. H. IVERY, *Secretary*

GLASS DIVISION NOMINATIONS FOR 1942–1943

Chairman: W. C. TAYLOR, Corning Glass Works, Corning, New York.

Vice-Chairman: C. W. PARMELEE, Department of Ceramic Engineering, University of Illinois, Urbana, Illinois.

Second Vice-Chairman: J. F. GREENE, Kimble Glass Company, Vineland, New Jersey.

Secretary: S. R. SCHOLES, New York State College of Ceramics, Alfred, New York.

WHITE WARES DIVISION NOMINATIONS FOR 1942–1943

Chairman: F. C. HENDERSON, Hall China Company, East Liverpool, Ohio.
Secretary: J. R. BEAM, Universal Sanitary Manufacturing Company, New Castle, Pennsylvania.
Nominating Committee A: S. J. McDOWELL, American Lava Corporation, Chattanooga, Tennessee.
Nominating Committee B: H. W. THIEMECKE, Homer Laughlin China Company, Newell, West Virginia.

INSTITUTE OF CERAMIC ENGINEERS

Executive Committee

President: E. H. FRITZ, Westinghouse Electric & Mfg. Co., Derry, Pa.
Vice-President: H. M. KRANER, Bethlehem Steel Co., Bethlehem, Pa.
Secretary: H. B. DUBOIS, Consolidated Feldspar Corp., Trenton, N. J.
Past-President and Trustee Representative: H. G. WOLFRAM, Porcelain Enamel & Mfg. Co., Baltimore, Md.
Past-President: A. F. GREAVES-WALKER, Dept. of Ceramic Engineering, Univ. of North Carolina, Raleigh, N. C.

NOMINATIONS FOR OFFICERS, 1942–1943

President: H. M. KRANER, Research Department, Bethlehem Steel Company, Bethlehem, Pennsylvania.
*Vice-President**
H. B. DUBOIS, Consolidated Feldspar Corporation, Trenton, New Jersey.
R. K. HURSH, Department of Ceramic Engineering, University of Illinois, Urbana, Illinois.
*Secretary**
H. Z. SCHOFIELD, Standard Tile Company, Zanesville, Ohio.
H. G. SCHURECHT, New York State College of Ceramics, Alfred, New York.

BUDGET FOR 1942

RESOURCES AND PROBABLE INCOME			
Estimated Balance, December 31, 1941		$850.00	
Assessment, $2.00 per Member		660.00	
TOTAL			$1,510.00
EXPENSES			
Traveling Expenses			
A.I.M.M.E. Meeting	$ 85.00		
S.P.E.E. Meeting	105.00		
N.C.S.B.E.E. (State Board of Examiners)	100.00		
TOTAL		$290.00	
Contribution to N.C.S.B.E.E.	$ 25.00		
Printing	75.00		
Postage	50.00		
Stenographic Service	25.00		
Contingent Fund	25.00		
TOTAL		200.00	
			490.00
Estimated Balance, December 31, 1942			$1,020.00

* One to be elected.

REPORT ON ANNUAL MEETING NATIONAL COUNCIL OF STATE BOARDS OF ENGINEERING EXAMINERS

The annual meeting of the National Council of State Boards of Engineering Examiners was held in New York, N. Y., October 27 to 30, 1941. The principal topics discussed at the meetings were (1) the need for increasing the income of the Council, (2) the development of a more professional attitude on the part of all engineers and particularly on the part of young graduates, (3) a requirement that all engineers subscribe to a code of ethics as the medical doctors and lawyers do, and (4) increasing efforts to have all qualified engineers registered whether in or out of industry.

Reports of the various boards indicate an increasing number of prosecutions for breaches of the licensing laws, particularly in the use of the title "engineer" by those not holding licenses.

There are now over 70,000 engineers registered in the United States. During the past year, Delaware, Massachusetts, Missouri, and Illinois have passed licensing laws. The act in Illinois does not go into effect until 1943. In all of these states, ceramic engineers may be licensed as "professional engineers."

In this connection, eligible ceramic engineers residing in the above-named states should obtain licenses under the "Grandfather Clauses." Under these clauses, applicants are not required to take oral or written examinations. Licenses are issued for a limited period on the basis of length of service and experience.

Although ceramic engineers holding industrial positions may not consider it worth while to obtain a license, it may become a valuable asset if they move into other states where a license may be necessary. Although reciprocity among the states is not general, many states do reciprocate and, in the others, the holding of a license makes it much easier to obtain professional status.

The secretary of the Michigan State Board advised that ceramic engineers would be eligible for licensing. Michigan is one of the states which heretofore has refused to license ceramic engineers.

The State Board of West Virginia does not register ceramic engineers, but a member of that Board stated that it was "softening up" somewhat.

The State Board of Virginia requested that we have a representative present at its next meeting on January 19, at which time ceramic engineers may be granted recognition. It desires further information, however, before acting. The law in Virginia does not include ceramic engineers and the Board is at a loss as to how to classify them within the law.

In South Carolina recently, the Board found it necessary to license a ceramic engineer as a mechanical engineer. The president of the Board stated that the applicant had no difficulty in qualifying as such.

The 1942 meeting of the National Council of State Boards will be held in Indianapolis, Indiana, and the 1943 meeting well be held in Phoenix, Arizona.

—A. F. GREAVES-WALKER, *Chairman, Committee on State Boards*

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CERAMIC SCHOOL NOTES

UNIVERSITY OF NORTH CAROLINA

Student Branch

Approximately fifty members were present when the freshmen and several sophomores were initiated as associate members at the November meeting of the North Carolina Student Branch. After the ceremonies, the new members were entertained at the annual Halloween party which was held in the ceramic laboratories.

At the business meeting held at the same time, President Charles Taylor appointed H. L. Miller and P. P. Turner as members of the Program Committee and R. J. Smith, Jr., was put in charge of publicity.

Keramos

The following students were initiated into the North Carolina Chapter of Keramos at the November meeting: C. V. Rue, G. D. Martin, R. J. Smith, Jr., E. C. Hepler, C. N. Kimball, R. B. Bickerstaff, and J. E. Partlow. Following the impressive initiation ceremonies, with President H. L. Miller in charge, the chapter held its annual General Edward Orton, Jr., memorial banquet at the Woman's Club. A. F. Greaves-Walker, who had just returned from installing the Iowa Chapter of Keramos, was the principal speaker. He told of General Orton's life, his establishment of the first department of ceramic engineering at Ohio State University, and his influence on his students. Professor Greaves-Walker also gave a brief history of Keramos.

IOWA STATE COLLEGE

Student Branch

The Iowa State College Student Branch held its annual fall picnic in October at the Ledges State Park in Boone, Iowa. A perfect day, good food, and a liberal portion of fellowship, mixed thoroughly, provided a lot of fun for everyone.

Russell Mathern, a senior, has been elected as senior representative to the engineering council to fill the vacancy left by Murner Thor, who at the present time is an airplane designer in a defense plant.

The Student Branch has augmented its treasury by annealing 9000 pounds of castings for one of the foundries working on defense materials. The money earned will be used for the Veishea Celebration which takes place in May.

Officers for 1941–1942 are Lawrence Van Vlack, *President;* Wayne Calderwood, *Vice-President;* Francis Newark, Jr., *Treasurer;* and Clyde B. Eller, *Corresponding Secretary.*

Keramos

A chapter of Keramos was installed at Iowa State College, Ames, Iowa, on November 15, 1941. The Installation Team was made up of the following members: Robert F. Sherwood, *Grand President;* Lane Mitchell, *Grand Secretary;* Arthur F. Greaves-Walker, *Past Grand President and Past Grand Herald;* Paul G. Herold; and C. M. Dodd, *Past Grand Secretary.* The petitioning members of the Iowa State Ceramic Engineering Professional Fraternity were Martin Baker, Edgar G. Nodurft, Lloyd Wells, Jr., Wayne Calderwood, Russell Mathern, Murner Thor, and Lawrence H. Van Vlack.

The present officers of the new chapter of Keramos are Lawrence H. Van Vlack, *President;* Russell Mathern, *Vice-President;* Wayne Calderwood, *Secretary;* William Faust, *Herald;* and Richard Boerner, *Treasurer.* These officers and H. J. Beckemeyer, instructor in the Department, were initiated by the Installation Team. Other petitioning members will be initiated in absentia.

The initiation, installation ceremonies, and installation banquet were held in the Memorial Union. The banquet speakers were Arthur F. Greaves-Walker, Robert F. Sherwood, Dean T. R. Agg, and Lawrence H. Van Vlack; C. M. Dodd acted as toastmaster. The heads of the engineering departments of Iowa State College were guests at the banquet.

With the installation of the Chapter at Iowa State College, Keramos now has six chapters; the others are located at Ohio State University, University of Illinois, New York State College of Ceramics, North Carolina State College, and Virginia Polytechnic Institute.

NEW YORK STATE COLLEGE OF CERAMICS

The meeting of the New York State College of Ceramics Student Branch held on December 16 was devoted to a competition among the seniors for the privilege of representing the College in the speech contest at the Annual Meeting of The American Ceramic Society in April. The winner was John Angevine, who spoke on "Uses of the Brabender Plastograph."

At the December meeting of Keramos, Willard J. Sutton gave an informal address on "Ceramics in China." Dr. Sutton, who joined the faculty of the New York State College of Ceramics last September, spent some time in Foochow, China, where he was in charge of ceramic and chemical work at the Fukien Christian University. His address was illustrated with slides and pieces of ware he had collected in China.

Garrison P. Smith succeeded Moe D. Cohen as managing editor of the *Alfred Engineer,* news organ of the Student Branch. The second edition of the term was published shortly after the Christmas recess.

Two juniors, Robert Sinclair and Francis J. DiLaura, were selected to work with the seniors of the Saint Pat's Board in sponsoring the annual Saint Pat's Festival to be held in March.

The ceramic artists held their annual exhibit and pottery sale on December 9; $475 was made at the sale. The Beaux-Arts Ball, a costume dance with an "Arabian Nights" theme, was held in the evening.

—LAWRENCE BICKFORD, *Corresponding Secretary*

MISSOURI SCHOOL OF MINES AND METALLURGY

The Missouri Student Branch held its monthly meeting on December 10 at the Missouri School of Mines and Metallurgy, Rolla, Mo. Leonard Bolz, a senior in the Department of Ceramic Engineering, told of his experiences while working for the Robinson Clay Product Co., Akron, Ohio. He also discussed the thermal analysis of fire clays.

The American Ceramic Society is sponsoring a speaking contest for students enrolled in ceramic engineering. The winner of this contest is to be determined at the Annual Meeting in Cincinnati. Several students have already expressed a desire to enter the contest.

—PAUL G. HEROLD, *Head, Department of Ceramic Engineering*

NEW YORK UNIVERSITY

Because the war has cut off important supplies of pottery and glass, New York University, in cooperation with leaders of the two industries, has planned a series of fifteen evening lectures on American design and manufacture of pottery and glassware. The lectures, scheduled from February 10 to May 19, will be under the direction of Albert Charles Schweizer, professor at New York University.

The series was arranged with the advice of a committee composed of H. L. Dillingham, American Glassware Association; H. L. Lissfelt, Corning Glass Works; Viktor Schreckengost, Limoges China Co.; S. H. Slobodkin, Cavitt-Shaw Pottery, Inc.; and Vignia Grmes and Alfred Auerbach, Retailing Home Furnishings. Firms in the pottery and glass industries will provide specialists to lecture on various phases of the subjects.

MEMBERSHIP RECORD

NEW MEMBERS FOR DECEMBER

Corporation

BUTCHER, L. H., Co., W. D. Schwartz (voter), 2030 Bay St., Los Angeles, Calif.

Personal

AMYLON, LEROY A., 1806½ Elmwood Ave., Norwood, R. I.; plant chemist, Corning Glass Works.

CLIMES, GEORGE L., 2966 E. Colorado Blvd., Pasadena, Calif.; president, Will-George Ceramic, Inc.

*FRIDERICHSEN, CHRISTIAN, 317 Lomita Ave., Glendale, Calif.; tile manufacturing superintendent.

GOETTMAN, FRANKLIN P., 1121 Queen St., Pottstown, Pa.; production control engineer.

LILLEY, GEORGE, 92 Brown St., Pawtucket, R. I.; melting foreman, Corning Glass Works.

MOSER, LEO, 250 West 91st St., New York, N. Y.

NETTER, WILLIAM S., Box 351, Aberdeen, Md.; mathematician, Aberdeen Proving Grounds.

SCHEIER, EDWIN, Box 342, Durham, N. H.; teacher, Univ. of New Hampshire.

STRIKOW, M. H., 646 N. Robertson Blvd., Los Angeles, Calif.; decorator.

VEITCH, LLOYD, 3799 Harrison St., Oakland, Calif.; operator, silica and glass sand plant.

Student

University of Alabama: E. J. BRIGANTI.
University of Illinois: WILLIAM E. SCHLAKE.
New York State College of Ceramics: JOHN S. ANGEVINE.
Pennsylvania State College: WILLIAM S. BATES.

* Indicates former member of The Society rejoining.

MEMBERSHIP WORKERS' RECORD

Corporation

William V. Knowles	1

Personal

R. E. Birch	1	J. B. Shimer	2
Donald Hagar	1	Woldemar Weyl	1
E. L. Maxson	4	Office	1

Student

A. I. Andrews	1	M. E. Holmes	1
H. M. Davis	1	T. N. McVay	1
		Grand Total	**15**

ROSTER CHANGES DURING DECEMBER†

ALBERT, JOSEPH, 1337 22d St., N. W., Washington, D. C. (Metter, Ga.)

AUSTIN, LEWIS M., 1124 New Pear St., Vineland, N. J. (Salem, N. J.)

† Address in parentheses is former address.

BARTLETT, E. E., Box 64, Brownsville, Tex. (Sapulpa, Okla.)

CRAMER, WILLIAM R., 5314 Holder Ave., Baltimore, Md. (York, Pa.)

CUNLIFFE, JACK A., A. P. Green Fire Brick Co., Ltd., Commercial St., Leaside, Toronto 12, Ontario, Canada (Winnipeg, Manitoba, Canada)

EARHART, WILLIAM H., Armour Research Foundation, 33rd, Federal & Dearborn Sts., Chicago, Ill. (Columbus, Ohio)

FORD, WALTER D., 61 Kathrine St., Port Allegheny, Pa. (Columbus, Ohio)

FRAHME, HERMAN H., Beechwood Place, Watchung, N. J. (Rahway, N. J.)

JEFFREY, G. H., Box 285, Washington, N. J. (Metuchen, N. J.)

KNAPP, ERNEST W., 324 Ridge Ave., Cambridge, Mass. (Boston, Mass.)

KOLSTAD, JOHN H., 11313 Lake Ave., Cleveland, Ohio (Parma, Ohio)

KOPPERS, HEINRICH, Research Dept., Koppers Co., Koppers Bldg., Pittsburgh, Pa. (Tokyo, Japan)

LAMBERTSON, WINGATE A., 7808 South Shore Drive, Chicago, Ill. (Ansonia, Conn.)

MASON, LLOYD W., 410 South Third St., Toronto, Ohio (Alfred, N. Y.)

McCUTCHEN, EARL S., Fine Arts Bldg., Univ. of Georgia, Athens, Ga. (Columbus, Ohio)

MERZ, GEORGE, Polish General Consulate, Buenos Aires, Argentina (Stockholm, Sweden)

MONTGOMERY, E. T., Box 145, Franklin, Ohio (Dallas, Tex.)

PERKINS, WALTER W., 600 DeWitt St., Linden, N. J. (Cincinnati, Ohio)

RADCLIFFE, B. S., 804 S. Kenilworth Ave., Oak Park, Ill. (Chicago, Ill.)

SCHOLES, WILLIAM A., 18930 Littlefield Ave., Detroit, Mich. (Chanute Field, Ill.)

SELLERS, GEORGE A., 1036 S. Harvey Ave., Oak Park, Ill. (Lansdowne, Pa.)

SHIMER, J. B., 16 Grant St., Wellsboro, Pa. (Pawtucket, R. I.)

SMOKE, JOSEPH E., 29 Bissett Place, Metuchen, N. J. (Perth Amboy, N. J.)

SOMMERVILLE, JAMES L., Owens-Illinois Glass Co., Alton, Ill. (Ft. Leonard Wood, Mo.)

STRAIGHT, LEE H., U. S. Army Rec. Camp, Forest Park, St. Louis, Mo. (Jefferson Barracks, Mo.)

TILLOTSON, CLIFFORD, Tillotson Refractories Co., 1112 West Sixth St., Corona, Calif. (Los Angeles, Calif.)

TUCKER, BRADFORD S., E. J. Lavino & Co., 1528 Walnut St., Philadelphia, Pa. (Lynchburg, Va.)

WALDSCHMIDT, MILTON H., 873 Ebner St., Columbus, Ohio (Fort Bragg, N. C.)

WEIS, J. H., Spruce Pine, N. C. (West Paris, Maine)

WHITTEMORE, O. J., JR., Mellon Institute, Pittsburgh, Pa. (Fort Dodge, Iowa)

WHITWOOD, ROBERT A., 206 Huntington Ave., Boston, Mass. (Buffalo, N. Y.)

SUBSTITUTION OF CERAMICS FOR METALS

The Procurement Branch of the Division of Contract Distribution of the Office of Production Management in Washington, D. C., is attempting to assemble an exhibit of materials which are plentiful and which can be substituted for the critical materials, most of which are metals. Harold D. Kube, special assistant in the Division, outlines the purposes of this substitution program and tentative methods for accomplishing these objectives.

Prime Objective

To stimulate the manufacturers who cannot get critical materials, and who therefore face the prospect of going out of business, into finding substitute materials which are plentiful and which can be used.

Other Purposes

(1) To conserve critical materials for defense uses.

(2) To stimulate the thinking of manufacturers, contractors, dealers, and the public as to the possibilities of using ceramic products in place of the products, made of vital materials, to which these various groups are accustomed.

(3) To keep companies in business and to meet consumer demands insofar as possible by providing satisfactory ceramic substitute materials where it is impossible to obtain materials made of metal and other strategic commodities.

Proposed Ways and Means of Accomplishing Objectives

(1) To prepare appropriate displays of ceramic materials which can adequately serve as substitutes for products consuming critical materials. Displays will be tentatively kept in Washington; they may later be placed on the "Defense Special Trains" on another tour of the United States and be placed in the various offices as permanent exhibits.

(2) The American Ceramic Society to present to the Division office a statement showing where ceramic material can serve as an adequate substitute in specifications which now call for the use of critical materials. This statement will be gone over carefully by impartial experts from the Division and then, in appropriate cases, will be taken up with the various procurement branches of the government.

(3) Division of Contract Distribution field offices or qualified technical men in Washington to survey facilities of manufacturers affected by priorities to determine whether these facilities are adaptable to the manufacturer of products made from ceramic materials.

(4) To establish procedures for informing field offices of case histories involving substitution and other related information. In this connection, methods should be devised to collect and coordinate information on the substitution of ceramic materials by the Washington organization to be distributed to field offices in usable form.

DEFENSE OF PROFESSIONAL STATUS OF CERAMISTS*

Through this discussion, an attempt is made to amplify the subject which has been brought up by R. C. Benner, Director of Research of The Carborundum Company, Niagara Falls, New York, regarding the need that exists for the protection of the interests of professional people and for the organization of the so-called intelligentsia in their own defense. The terms "professionals" and "intelligentsia" as such are very broad. To be specific, in the present instance we are concerned with the interests of ceramists and ceramic engineers and, incidentally, of others who might be sufficiently closely allied in interest with such persons to make common cause with them for mutual self-defense. This might include, to some degree, all professionals who earn a livelihood by the investigation of scientific phenomena or by the application of such phenomena to practical ends.

The next point to be settled is—protection of what interests against whom, or against what? The answer is that this is primarily an economic discussion, and the defense which is needed is defense against anything that will tend to lower the living standards of the group in which we are interested as compared with those of other members of the community and particularly defense against any legal prohibition of the normal activities of this group which would impose on them an artificial economic handicap.

As to defense against whom, the first line of defense would appear to be against pressure groups made up from other sections of the intelligentsia as distinguished from manual laborers. Examples of this will be given later. Secondly, defense may be needed against labor groups who at the present time are in a strongly entrenched governmental position and are definitely squeezing the unorganized members of society.

Mechanism Used by Pressure Groups

We are all familiar with the economic law of supply and demand. These two factors are interrelated by economic law in such a way that demand and price increase as the available supply of anything diminishes. American experience has long shown that, although the scientific principle underlying this so-called law cannot be repealed, the factors of supply and demand, and particularly supply, can be so controlled as to upset seriously the free operation of the law to the material comparative advantage of certain groups. This has been done for years through the imposition of tariffs and by the restriction of immigration and is being steadily extended in the domestic field by artificially reducing the number of people who are available to do a given job. This is done in some instances by preventing the training of apprentices, in other cases by picketing and physical force, and in others, by the imposition of legal barriers whereby persons who might perform specified services are prohibited by law from doing so. By whatever means the restriction is accomplished, the result is to put the people who remain in the field in a position to demand higher compensation for their services and to force those who are ruled out to work as subordinates for less, or to go elsewhere.

And here is the point of the matter, bluntly stated. We want to be sure that when fences are built, *we are on the right side of them.*

Numerous examples of such legal barriers are available. These particular ones cited in the next three paragraphs may not have troubled ceramists greatly, but they will illustrate the principle.

A number of years ago, the architects had a law passed whereby any plan for a building must be signed by an architect in order that its erection might be legal. This took away from the engineers who designed these buildings for specific purposes a definite field to which they were justly entitled. The matter was rectified only when the engineers (as an organization) secured repeal of the bill. The engineers now employ a permanent professional observer in Albany to scrutinize every bill presented and post their appropriate committees throughout the state in time to prevent further raids on their rightful province.

Another example, which occurred this last summer, was the attempt by the Bar Association to have a law enacted whereby all persons appearing before any government agency must be members of the bar. This would have ruled out a large number of patent attorneys who are technically proficient for the work but who are not members of the bar. A number of these men are members of The American Ceramic Society. The same bill would also have ruled out certified public accountants and other men who have spent many years practicing before other government agencies such as the Interstate Commerce Commission.

Another example is the recent attempt in Pennsylvania to insist that anyone running a clinical testing laboratory (pathology or bacteriology) must be a medical doctor, even though the work is inherently that of a chemist rather than of a medical man. There are, of course, numerous instances of a minor racket of the medicos by which remedies that have been household terms for many years are now available only on medical prescriptions, e.g., paregoric.

Defense Mechanisms

One of the early steps taken by many groups which desire to insure their economic stability is some form of licensing. This provides a clear distinction as to who "belongs" and who does not, permits the imposition of authoritative standards of proficiency, and allows some

* By George J. Easter, Assistant Director of Research, The Carborundum Company, Niagara Falls, N. Y.

of the functions of the group to be forbidden to the unqualified under the law. Perhaps this cannot be done for ceramists other than ceramic engineers, but the question would appear to deserve study. In New York State, it has been done for lawyers, doctors, professional engineers, trained nurses, public accountants, dentists, druggists, optometrists, shorthand reporters, realtors, architects, and surveyors. The licensing of chemists is being widely debated and, if undertaken, will doubtless strike rather close to some members of the ceramic profession.

Another item of direct economic concern to ceramists, and particularly the younger men, is the matter of union membership. The traditional attitude of all professions has been to stay out of the unions. Waiving for the moment the question of whether or not this attitude is for their best good, we may note that in many cases a man in a subordinate position now has no choice, but is compelled to join and pay dues to a union. This may put him in a distasteful situation from which he has no escape unless one can be found by his organized professional associates. At the present time, the professional engineers in the State of New York have a committee studying the possibility of getting the state educational board to render a recent engineering graduate legally a "professional" so that he will have more freedom when it comes to union activities.

The American Chemical Society is now trying (by means which appear rather ineffective) to establish salary "floors" (as opposed to ceilings) for certain types of chemists. This is an important economic move which warrants study. Any attempt to put teeth in it will unquestionably bring down the wrath of offending employers on the Society, but it is a new departure for organizations of this type and gives the chemist at least a nominal champion in his battle for a living. It is prominent among the steps which have attracted 3000 new members into the Society within the year. The extent to which the action might be emulated or improved upon by The American Ceramic Society is a question for serious thought.

Proposed Action

Now that the problem has been stated rather broadly, it seems in order to make concrete suggestions as to what might be done in the future.

(1) The first thing, of course, is to decide that *something* is to be done. The detailed nature of any program of action can be worked out later after careful thought and open discussion by The Society as a whole. We should not follow the practice of the American Chemical Society, wherein the editor, H. E. Howe, expresses his opinion at length in such matters, but will print no discussions by anyone else. The subject is too complex and its importance too vital to have any one man, no matter how gifted, hand down a solution to be followed by a profession whose members have had no voice in its formulation. Discussion, however, should be constructive and not merely consist of objections to proposals offered in such terms as "Can't it be done some other (unspecified) way?"

(2) Once it is established that some action is to be taken, our suggestion for an opening move would be to devote an hour or two at the Annual Meeting of The Society to an open discussion of the subject, starting with two or three prepared discussions which should be read, not given extemporaneously, inasmuch as the fundamentals should be thought out and the results concisely expressed.

(3) Another obvious step is to provide means by which we can act and act rapidly in case of necessity to protect ourselves from the encroachment of other groups which might be called "pressure groups." Let us consider, for example, the case of the legislation which would have deprived properly qualified but nonlawyer ceramic engineers of the right to appear before the Patent Office. This would have injured these individuals and deprived ceramic employers of the services of trained men (who are certainly better prepared to discuss ceramic technology than mere lawyers, to whom the business would perforce have gone).

To show the danger involved, the response from the New York Patent Law Association Committee when the question was brought to their attention is quoted as follows:

> ". . . the view more commonly held is that it should be possible to secure representation by a man who is well trained in the law and is sufficiently well trained on the scientific side to enable him to understand and absorb and make use of technical matters supplied to him by his client."

We were particularly disturbed in this instance by the "Let George do it" attitude of the chairman of the Patent Committee of The Society, Fulton B. Flick, who wrote as follows:

> ". . . this matter is of importance to so many nonlawyers who are registered to practice before the Patent Office that I think it can be taken for granted that sufficient action will be taken to persuade the Senate Judiciary Committee to amend the bill so that practice before the Patent Office will not be affected. . . . .
>
> "In view of this I do not know whether it would be worth while for our Committee to bring in a report that could be submitted to the Senate Judiciary Committee in behalf of The Society, or whether, if we were to bring in a report at this time, it could be approved as representing The Society's views."

An active, aggressive committee with authority to act on its own responsibility is required to deal with such matters. It would be desirable, incidentally, for the members of it to be located close together geographically to facilitate verbal discussion and action.

Another attitude with which we have no sympathy is the one taken by the American Institute of Mining and Metallurgical Engineers to the effect that they cannot attempt to influence legislative matters lest they render the property of the Society liable to taxation which they otherwise escape and make the membership dues of the members no longer a subject for income tax deduction. It would appear that, in comparison, the harm which would result to the profession in the absence of constructive united action on hostile legislation would far outweigh the amount of money which would be involved in taxes to the Society and certainly would outweigh any minor income tax deductions of the individual members.

All in all, it seems that they are about ten years behind the times. These are competitive times in which victory goes to organized groups. If our existing societies cannot be economic as well as scientific instruments, we must build new ones which will substantially parallel the present ones in membership. Is it not better to use our existing organizations for both purposes? Are we not sufficiently united in purpose for all to profit by the arrangement? Would not a knowledge that a man's economic interests were being looked after draw many additional members into our Society?

NOTES FOR CERAMISTS

CERAMIC ASSOCIATION OF NEW JERSEY

The annual meeting of the Ceramic Association of New Jersey was held on December 19, 1941, in the Ceramics Building, Rutgers University, New Brunswick, N. J.

The following program was presented:

(1) Address by the President: "Metals, Plastics, and Ceramics" by G. C. Betz, Star Porcelain Co., Trenton, N. J.

(2) "Radiant Heat in Pottery Drying: Experimental Results and Some Possibilities for the Future" by G. A. Hess, Public Service Electric & Gas Co., Trenton, N. J.

(3) "Dielectric Behavior of Some Ceramic Insulation" by S. O. Morgan, Bell Telephone Labs., New York, N. Y.

(4) "Relationship Between Composition and Dielectric Properties of Some Low-Loss Ceramics" by M. D. Rigterink, Bell Telephone Laboratories, New York, N. Y.

(5) "Some Experiences in Fine Grinding" by John L. Speirs, International Pulverizing Corp., Moorestown, N. J.

Richard C. Reager, Rutgers Univ., was the guest speaker at the luncheon held at noon at the Roger Smith Hotel.

CENTRAL DISTRICT ENAMELERS' CLUB

The Central District Enamelers' Club has elected the following officers for 1942:

President: Norman H. Stolte, Davidson Enamel Products, Inc., Clyde, Ohio.

Vice-Presidents:

Claude Cleghon, Davidson Enamel Products, Inc., Clyde, Ohio.

Dan Gredys, Perfection Stove Co., Cleveland, Ohio.

Jack Trees, Holland-Rieger Corp., Sandusky, Ohio.

R. E. Taylor, Enamel Products Co., Cleveland, Ohio.

John Reimers, Pfaudler Co., Elyria, Ohio.

Secretary-Treasurer: Burton Longwell, Republic Steel Corp., Cleveland, Ohio.

The next meeting of the Club will be held on February 6, 1942, at the Allerton Hotel, Cleveland, Ohio.

EASTERN ENAMELERS' CLUB

The Eastern Enamelers' Club has elected the following officers for 1942:

President: George Weise, Standard Gas Equipment Corporation, Baltimore, Maryland.

Vice-President: Nathan Klein, Caloric Gas Stove Works, Philadelphia, Pennsylvania.

Secretary: George Dwyer, Floyd-Wells Company, Royersford, Pennsylvania.

CHICAGO DISTRICT ENAMELERS' CLUB

The Chicago District Enamelers' Club held a luncheon meeting on December 6, 1941, at the Graemere Hotel, Chicago, Illinois.

The following program was presented:

(1) "Welding Practice for Porcelain Enameling" by Andrew Grierson, master mechanic, Norge Div., Borg-Warner Corp.

(2) "Examination of Welds by X-Ray Methods" by a representative of the X-Ray Diffraction Laboratory, General Electric X-Ray Corporation.

(3) "First Aid in Your Plant" by J. G. Brown, American Red Cross.

Through the cooperation of Lieutenant E. W. Dietterle, former vice-president of the Chicago District Enamelers' Club, a group of army men provided musical and comedy entertainment as an added attraction.

NEW YORK SOCIETY OF CERAMIC ARTS

The New York Society of Ceramic Arts will hold a series of lectures early in 1942 at the Metropolitan Museum of Art, New York, N. Y. The lectures will be given on Wednesday afternoons at 3:00 P.M.

Mrs. Eva S. Zeisel, Department of Industrial Design, Pratt Institute, Brooklyn, New York, inaugurated the series on January 14 when she presented an illustrated lecture on "Handicraft and Mass Production." Mrs. Zeisel studied at the Hungarian Academy of Fine Arts and learned pottery as an apprentice in a handicraft pottery shop. She then worked for twelve years in different factories where she made artware, dinnerware, and lamp fixtures in terra cotta, earthenware, and vitrified body. She learned the process of designing for mass production during her work in these plants.

The second lecture will be given on February 11 by Joep Nicolas, one of the foremost stained-glass designers of Europe, who came to the United States in 1939. Some of his outstanding work has been exhibited from time to time at the Orrefors Galleries in New York. At the present time, Mr. Nicolas is designing a series of thirty-six windows for the Fairmont Presbyterian Church near Cleveland, Ohio, and is working on a number of projects for individuals.

The third lecture will be given on March 4 by Howard Ketcham, a color engineer who has done outstanding work in color research and on the application of color engineering to industrial products. Mr. Ketcham, who has been engaged exclusively for more than twelve years in stimulating sales through the scientific use of color, has won new markets and has revived old ones for many products in this country.

The three lectures are open to the public, and members of The American Ceramic Society are particularly invited.

RESEARCH STAFF APPOINTMENTS AT ARMOUR RESEARCH FOUNDATION

The Armour Research Foundation, Chicago, Ill., announces the appointment of William H. Earhart as ceramist in the Metallurgy Section. Dr. Earhart, who is a graduate of Ohio State University, Columbus, Ohio, has been associated with the Edward Orton, Jr., Ceramic Foundation in Columbus.

Clark E. Thorp, formerly in charge of research for the Ozo-Ray Process Corporation, has joined the staff of the Chemical Engineering Section of the Foundation to study unit processes and pilot plant development.

TOLL OF 1940 INDUSTRIAL ACCIDENTS

"The toll of 1940 industrial accidents amounted to nearly 1,890,000 workers killed or injured at their jobs in the United States, according to estimates of the U. S. Bureau of Labor Statistics. If the economic time loss caused by deaths and permanent disabilities is excluded, the Bureau estimates that the employee-days lost in actual absence from work would be 41,912,000—enough to have provided 140,000 workers with full-time employment during the entire year. If standard time charges are applied for deaths and permanent impairments, the total time loss is increased to the tremendous total of 233,840,000 days, equivalent to full-time annual employment for about 780,000 workers—about 95% of the increase in employment during 1940.

"An analysis of the types of injuries and the industries in which they occurred is given in 'Industrial Injuries in the United States during 1940' by Max D. Kossoris and Swen Kjaer, U. S. Bureau of Labor Statistics, a reprint from the *Monthly Labor Review*, August, 1941." (From *Industrial Standardization*, November, 1941.)

SCHEDULE OF CERAMIC SHOW DATES

1. New York Lamp Show, Hotel New Yorker, New York, N. Y., January 19–23.
2. California Gift and Art Show, Biltmore Hotel, Los Angeles, Calif., January 25–28.
3. Chicago Gift Show, Palmer House, Chicago, Ill., February 2–13.
4. Merchandise Mart Gift Show, Chicago Merchandise Mart, Chicago, Ill., February 2–14.
5. San Francisco Gift Show, Palace Hotel, San Francisco, Calif., February 8-11.
6. Seattle Gift Show, Olympic Hotel, Seattle, Wash., February 22–25.
7. Allied Gift Show, Adolphus Hotel, Dallas, Tex., February 22–27.
8. Dallas Gift Show, Baker Hotel, Dallas, Tex., February 22–27.
9. New York Gift Show, Hotel Pennsylvania, New York, N. Y., February 23–27.
10. 225 Fifth Avenue Gift Show, 225 Fifth Ave., New York, N. Y., February 23–27.
11. Boston Gift Show, Hotel Statler, Boston, Mass., March 9–13.
12. Philadelphia Gift Show, Hotel Benjamin Franklin, Philadelphia, Pa., March 23–27.

MINIATURE POTTERY AND ITS POTTING*

By Margaret Steenrod Fetzer

Abstract

An illustrated adventure in the making and enjoyment of pottery miniatures.

I. Introduction

Without detraction from the merits of large pieces, one can truly say that an object need not be large to be beautiful. Miniatures may have incorporated in them beauty of design plus the attractiveness of minute careful carving which is of interest and which might be lost on a large piece or make it look "overdressed."

II. Process for Miniature Work

The act of throwing a miniature on a potter's wheel, compared to the same performance in shaping larger pieces, gives an added thrill. The beginning of the miniature is a ball of clay no larger than a marble or at most no more than $1^1/_2$ in. in diameter. Three finger tips serve to center the "ball" (Fig. 1) (see p. 13). The concentric lines on the wheel head are $^1/_2$ in. apart, which gives an idea of the relative size. Instead of a full complement of thumbs and fingers with which to fashion the cylinder, two fingers only are used (Figs. 2 and 3). The bottom is bulged out with the little finger, and any excess clay at the base is cut away with a flat, slightly hooked strip of steel (Fig. 4). While there is still room to manipulate a tiny sponge, surplus water is removed. By continued squeezing and pulling between the side of one finger and a small round stick (Figs. 5, 6, and 7), the neck of the pot, now destined to become a jug, grows smaller and smaller. Finished off with a "rib" (Fig. 8) and an elephant-ear sponge (Fig. 9), the jug is cut from the wheel with a thread and is transferred, by

Fig. 11

Fig. 12

* Presented at the Forty-Third Annual Meeting, The American Ceramic Society, Baltimore, Md., April 2, 1941 (Art Division). Received November 12, 1941.

FIGS. 1–10.

FIG. 13.

FIG. 14.

means of a spatula, to a tile. After drying a short time, the piece is ready to receive the handle (Fig. 10).

III. Enjoyment of Results

Certain interesting glaze textures and colors look best on miniatures; these include crystals, aventurines, and bright colors, such as red and alkaline blue. To give some idea of the variety of shape and glaze, a few groups of pieces are shown in Fig. 12. The ring has been included for scale comparison. The elephant plate and the bottle with the head stopper are low fire, and all of the others are fired at cone 9. The three blue bottles in the group shown in Fig. 11 are of unglazed polished body with inlaid decoration. In the salt-glaze group (Fig. 13), the smaller of the two large jugs and the three little ones in front were made by the author. The ten little brown jugs in Fig. 14 are of high-fire porcelain.

A potter's natural impatience to discover the effects of firing is humored by the shorter time required, and with miniatures it is not necessary to wait long after the kiln gets dark to remove them. This feature lends itself to the satisfactory testing and recording of new glazes for which miniatures are well adapted.

When the miniature is completed and ready to be admired, its disposal is not a problem, and the need for storage space does not present itself. A few cigar boxes suffice for several years' output.

If an excuse should be needed for making miniatures other than that of pure enjoyment, certain shapes are in demand for miniature flower arrangements, whatnots, miniature jugs for patent beverages, perfumes, and for gifts of quality rather than quantity.

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Vol. 25 January 15, 1942 No. 2

PROPERTIES OF WARE VERSUS THERMAL HISTORY: I, TESTS ON VITREOUS CHINA BODIES AND WARE*

By J. H. Koenig

Abstract

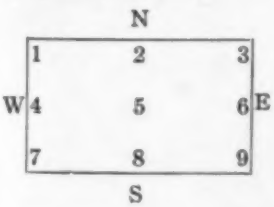
The properties of ware, which were given different thermal treatments, have been compared. The tests include shrinkage, flexural strength, elasticity, thermal expansion, moisture expansion, microstructure, glaze stress, and glaze microhardness. The variations in these properties occurred as a result of differences in (1) supposedly similar firings, (2) the uniformity of the kiln from end to end, (3) the same firing in the cross section of the kiln caused by uneven heat distribution, (4) the rates of firing to the same cone deformation, and (5) repeated firings.

I. Procedure and Test Data

(1) Specimens Fired 37.2 Hours in Muffle Kiln

Several thousand round rods (1 in. in diameter) were extruded from the same sample of a vitreous china body, and a large number of rings, such as those used in the glaze-fit test, were cast. Sets of these specimens were given various thermal treatments.

Seven flexural and shrinkage test specimens and two rings with the same glaze were placed in 45 different positions on a car and were fired through a Dressler muffle kiln in 37.2 hours. The specimens were placed in nine positions on each deck of a five-deck car as shown on the chart.



A cone plaque was placed with the specimens in each position. The cone deformations are shown in Table I. Table II shows the flexural strength, absorption, and firing shrinkage with this heat-treatment. The ring test data are discussed in section V, p. 39.

(*A*) *Cone Temperatures:* The cone temperatures on the top three decks were strikingly similar, and the fourth top deck also showed uniform cone deformation but lower than the three decks above. The fifth top (or bottom deck) was approximately one cone lower than the fourth top deck. Too much importance should not be assigned to the small variations in the upper decks inasmuch as the cones may vary slightly in their deformation. The extra space on the car decks was placed as uniformly as possible with the same type of ware. A definite gradient, however, occurs in the heat work (cone deformation) and is reflected in the properties. The west end of the car received more heat work than the east end, and the center was intermediate. In the greater number of rows in respect to width, the center position showed the lowest cone deformations. By rows in respect to car width, 10 out of 15 positions showed the same deformation in the north and south positions; three of the north positions were hotter; for the other two positions, the south position was hotter. By rows in respect to car length, the greatest uniformity occurred in the two outside rows on the bottom deck. Evaluating by decks for all positions, the second and third decks were nearly the same, the top deck but slightly less, the fourth top deck definitely lower, and the bottom deck considerably lower as previously mentioned. Evaluating by positions for all decks, 1 and 7 were the hottest, 2 and 8 and 3 and 9 next in order; of the center positions of all decks, 4 was the highest, 5 next, and 6 the lowest.

(*B*) *Flexural Strength:* The flexural strength averages for decks showed the first three top decks of the same order of magnitude, the greatest strength corresponding to the top deck, the next to the second top. The third top deck was slightly less, the fourth top deck was noticeably less, and the bottom deck was markedly lower. Evaluating by positions for all decks, 1 and 7 were the highest, 2 and 8 were next, then 3, 4, and 5 of the same order, with 6 and 9 the lowest. Although this

* Presented at the Forty-First Annual Meeting, The American Ceramic Society, Chicago, Ill., April 17, 1939. (Symposium on the Importance of Thermal History). Received August 18, 1941.

order is not completely in accord with the rating of cone deformations, the agreement is marked, and again the west end of the car received the most heat work and the east end less heat work.

(*C*) *Absorption:* The averages for absorption showed that the lowest occurred in the top deck. The first three top decks were of the same numerical order; the second top was slightly greater than the top; and the third top was slightly greater than the second top, which is in accordance with the results given for flexural strength. The fourth top deck had definitely higher absorption than the three upper decks. The bottom deck had a much higher absorption value (average 1.56%). Evaluating by positions for all decks, 1 and 7 were lowest in absorption; 3, 8, and 9, slightly higher; and 3 and 4, of the same order and slightly higher than the previous group. The other two center positions, 5 and 6, were markedly higher, with 6 the highest. This order agrees in general with the vitrification as gauged by the strength. Out of order, however, are 4 and 9; this discrepancy was due to small differences in numerical value.

(*D*) *Firing Shrinkage:* The averages for firing shrinkage rated the decks from the highest to the lowest shrinkage as follows: 2d top, 3d top, 4th top, and 5th top decks. The top deck and third top were practically the same; the fourth top again was definitely lower; and the bottom deck showed markedly lower shrinkage (as was found also for strength). Evaluating for positions on all decks, the position order starting with the highest shrinkage was 1, 2, 7, 4, 5, 3, 8, 6, and 9.

TABLE I

CONE DEFORMATIONS OF SPECIMENS FIRED 37.2 HOURS IN FORTY-FIVE DIFFERENT POSITIONS

	Deck positions								
	1	2	3	4	5	6	7	8	9
Top deck	13^3	13^3	13^3	13^3	13^1	13^2	13^3	13^3	13^2
2d top	13^4	13^3	13^3	13^3	13^2	13^3	13^4	13^3	13^3
3d "	13^4	13^3	13^3	13^3	13^2	13^2	13^3	13^3	13^2
4th "	13^1	13^1	12^5	12^5	13^1	12^3	13^1	13^1	13^1
5th "	12^1	12^1	12^1	11^6	11^4	11^4	12^1	12^1	12^1

TABLE II

DATA ON FLEXURAL STRENGTH, ABSORPTION, AND FIRING SHRINKAGE

Deck positions	Top deck	2d top	3d top	4th top	5th top	Positions on all decks (avg.)
			Flexural strength (lb./sq. in.)			
1	10,382	10,679	10,691	10,084	7387	9845
2	10,445	10,489	10,492	10,104	7165	9739
3	10,300	10,335	10,433	9,746	7193	9600
4	10,657	10,429	10,537	9,584	7000	9641
5	10,243	10,413	10,444	9,997	6985	9616
6	10,395	10,277	9,960	8,776	6843	9250
7	10,566	10,509	10,504	10,179	7366	9825
8	10,643	10,324	10,159	10,057	7190	9675
9	10,564	10,236	9,864	9,766	7005	9487
Avg.	10,466	10,410	10,343	9,810	7126	
			Absorption (%)*			
1	0.039	0.019	0.030	0.080	1.432	0.320
2	.024	.034	.039	.072	1.538	.341
3	.049	.051	.052	.147	1.490	.358
4	.021	.039	.030	.104	1.585	.356
5	.044	.043	.033	.061	1.721	.380
6	.029	.043	.048	.169	1.976	.453
7	.021	.027	.029	.063	1.400	.308
8	.023	.030	.041	.083	1.453	.326
9	.030	.036	.046	.088	1.460	.332
Avg.	.031	.036	.039	.096	1.562	
			Firing shrinkage†			
1	8.67	9.02	9.12	8.69	8.38	8.78
2	8.59	8.59	8.80	8.80	8.03	8.56
3	8.51	8.59	8.38	8.30	8.27	8.41
4	8.71	8.59	8.60	8.27	8.06	8.45
5	8.59	8.69	8.51	8.59	7.83	8.44
6	8.38	8.75	8.35	8.06	7.74	8.25
7	8.58	8.80	8.38	8.70	8.28	8.55
8	8.27	8.59	8.27	8.38	8.17	8.34
9	8.17	8.38	8.27	8.27	7.83	8.18
Avg.	8.50	8.67	8.52	8.45	8.07	

* Absorption tests were run on broken flexural strength pieces.
† Dry basis (%) used 10-cm. shrinkage marks applied with special vernier caliper.

(2) Specimens Fired 42 Hours in Multiburner Direct-Fire Kiln

A similar experiment was carried out firing the specimens in 45 different positions on a car through a Dressler multiburner direct fire kiln in 42 hours. The cone deformations are shown in Table III. Table IV shows the flexural strength, absorption, and firing shrinkage for this heat-treatment.

The absorption values on all specimens were quite low and in a range where experimental error can be easily introduced. The averages for decks showed that the lowest value occurred in the top deck and the highest value in the bottom deck; the intermediate decks were in the order of increasing absorption from the top to the bottom deck; the difference, however, between the averages was quite small. There was little difference in the averages for strength and firing shrinkage on all of the decks. These properties of the specimens

FIG. 1.—Cone deformation on various car decks for a cone 12 and a cone 13 firing; (1) top deck; (2) 2d top; (3) 3d top; (4) 4th top; (5) 5th top.

TABLE III

CONE DEFORMATIONS OF SPECIMENS FIRED 42 HOURS IN FORTY-FIVE DIFFERENT POSITIONS

	Deck positions								
	1	2	3	4	5	6	7	8	9
Top deck	13^{6}	13^{6}	13^{6}	13^{6}	13^{6}	13^{6}	13^{6}	13^{6}	13^{5}
2d top	13^{6}	13^{6}	13^{6}	13^{6}	13^{6}	13^{6}	13^{6}	13^{6}	13^{6}
3d "	13^{5}	13^{5}	13^{4}	13^{4}	13^{5}	13^{4}	13^{5}	13^{3}	13^{3}
4th "	13^{3}	13^{2}	13^{3}	13^{2}	13^{2}	13^{3}	13^{2}	13^{3}	13^{3}
5th "	13^{3}	13^{3}	13^{3}	13^{1}	13^{1}	13^{1}	13^{1}	13^{3}	13^{3}

TABLE IV

DATA ON FLEXURAL STRENGTH, ABSORPTION AND SHRINKAGE

Deck positions	Top deck	2d top	3d top	4th top	5th top	Avg.
			Flexural strength (lb./sq. in.)			
1	10,469	10,559	10,729	10,585	10,605	10,589
2	10,366	10,708	10,796	10,645	10,679	10,639
3	10,475	10,410	10,594	10,449	10,617	10,509
4	10,331	10,432	10,499	10,470	10,219	10,390
5	10,380	10,015	10,556	10,469	10,219	10,328
6	10,378	10,401	10,493	10,552	10,396	10,444
7	10,459	10,523	10,520	10,520	10,324	10,469
8	10,575	10,638	10,129	10,515	10,588	10,489
9	10,277	10,425	10,415	10,518	10,843	10,496
Avg.	10,412	10,457	10,526	10,525	10,499	
			Absorption (%)			
1	0.003	0.007	0.007	0.011	0.014	0.008
2	.003	.005	.008	.005	.003	.005
3	.008	.007	.010	.009	.019	.011
4	.006	.014	.008	.015	.020	.013
5	.007	.014	.010	.013	.017	.012
6	.012	.009	.015	.011	.017	.013
7	.006	.011	.008	.009	.016	.010
8	.002	.009	.009	.016	.016	.010
9	.007	.005	.015	.014	.010	.010
Avg.	.006	.009	.010	.011	.015	
			Firing shrinkage (%)			
1	8.52	8.68	8.75	8.69	8.81	8.69
2	8.56	8.53	8.68	8.86	8.71	8.67
3	8.68	8.75	8.69	8.47	8.62	8.64
4	8.63	8.60	8.46	8.46	8.64	8.56
5	8.54	8.41	8.64	8.63	8.51	8.55
6	8.45	8.88	8.61	8.63	8.52	8.62
7	8.43	8.74	8.66	8.39	8.68	8.58
8	8.57	8.58	8.51	8.64	8.61	8.58
9	8.69	8.70	8.67	8.66	8.48	8.64
Avg.	8.56	8.65	8.63	8.60	8.62	

fired were uniform throughout the cross section and length of the car.

Figure 1 indicates the uniformity of cone deformation on two firings through the multiburner kiln. Cone plaques were placed in the same relative position on each car deck.

(3) Specimens Fired 46.5 and 62 Hours in Multiburner Direct-Fired Kiln

Additional data are given for specimens placed in the same relative position (one position) on different car decks in different firing treatments.

Specimens fired in a multiburner direct-fired kiln in 46.5 hours gave results as shown in Table V.

TABLE V

DATA ON SPECIMENS FIRED 46.5 HOURS

Deck	Cone deformation	Absorption (%)	Flexural strength (lb./sq. in.)	Linear firing shrinkage (%)
Top deck	12^4	0.056	9874	8.48
2d top	12^3	.109	8985	8.27
3d top	12^2	.114	8753	8.27
4th top	12^1	.145	8012	8.17
5th top	11^{4+}	.187	7932	8.06

Table VI shows the results obtained from firing specimens in the same kiln on a 62-hour firing at cone 10 in order to study the firing range of this body.

TABLE VI

DATA ON SPECIMENS FIRED 62 HOURS AT CONE 10

Deck	Cone deformation	Absorption (%)	Flexural strength (lb./sq. in.)	Linear firing shrinkage (%)
Top deck	10^3	1.96	8500	8.06
2d top	10^3	2.54	8306	7.63
3d top	10^3	2.38	8135	7.42
4th top	10^3	2.44	8050	7.74
5th top	10^1	2.77	7649	7.53

The properties were fairly uniform from top to bottom on this firing. The strength regularly decreased from top to bottom, the absorption increased fairly regularly, and the shrinkage data appeared to be erratic.

A comparison of data on a large number of specimens is given in Table VII.

The strength and shrinkage are somewhat higher and the absorption is lower for the faster firing of this vitreous body. The differences are quite small although 70 specimens were tested in each case.

TABLE VII

COMPARATIVE DATA ON PROPERTIES OF SPECIMENS FIRED IN MUFFLE AND MULTIBURNER KILNS

	Muffle kiln	Multiburner kiln
Firing time (hr.)	37.2	42
Cone deformation	13^1	13^1
Linear drying shrinkage (%)	6.00	5.95
Linear firing shrinkage (%)	8.51	8.48
Total linear shrinkage (%)	14.51	14.43
Fired flexural strength (lb./sq. in.)	10796	10425
Absorption (%)	0.063	0.068

II. Effect of Repeated Firings

These tests are valuable from the standpoint of changes undergone in the properties of ware that is refired to correct slight defects as well as to study the characteristics of the body.

A set of specimens was fired repeatedly in the same relative car position through a muffle kiln in 37.2 hours. To illustrate the removal of specimens at different cycles for testing, the specimens were placed in a row and numbered from 1 to 100; with each cycle, 10 bars were removed in the order given as follows:

Cycle No.	Bars removed
1	1, 11, 21, 31, 41
2	2, 12, 22, 32
3	3, 13, 23

The remaining specimens were placed as closely together as possible, which increased the uniformity of thermal history. The data are plotted in Fig. 2.

When specimens of different bodies are being compared, they should be staggered, i.e., one of body A, one of body B, one of body C, and starting again with body A, etc., to obtain better equalization of treatment.

Another set of specimens was fired repeatedly through a multiburner kiln, the first 10 cycles in 42 hours and the last 6 cycles in 63 hours (see Fig. 3).

After the repeated firings, the vitreous china body became somewhat more absorptive, underwent a slight expansion, and increased noticeably in strength. The

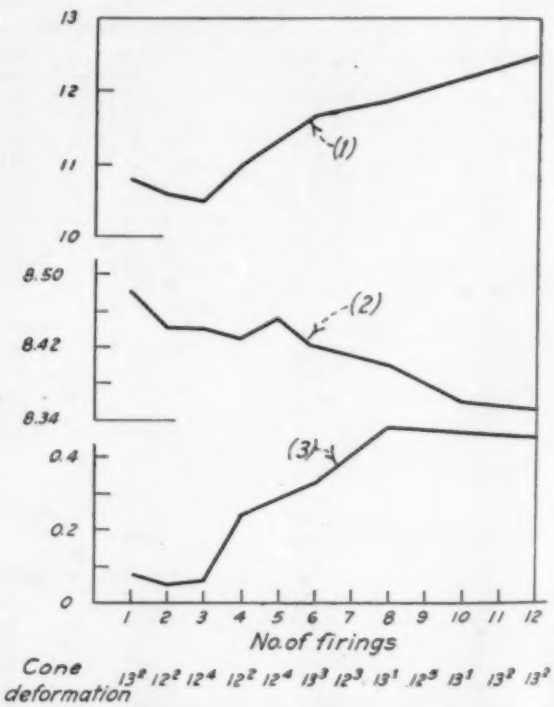


FIG. 2.—Effect of repeated firings on properties of vitreous china body (faster firing); *curves:* (1) flexural strength × 10^4; (2) firing shrinkage (%), decrease represents expansion; (3) absorption (%).

increase in strength may have resulted from the development of a more favorable structure (Fig. 6) or from the formation of an extremely thin vitreous film on the surface which was acquired from glaze fumes in the kiln and from progressive vitrification. Some of the specimens after 12 and 16 firings appeared to have a barely noticeable glassy surface. Such a thin film developed after prolonged firing might exert a beneficial effect from the stress angle and might also cover body discontinuities to eliminate focal points for initial failure. When the specimens used in strength tests were broken, the fracture seemed to become smoother with progressive firings; continued quartz solution and more crystalline development would also be expected.

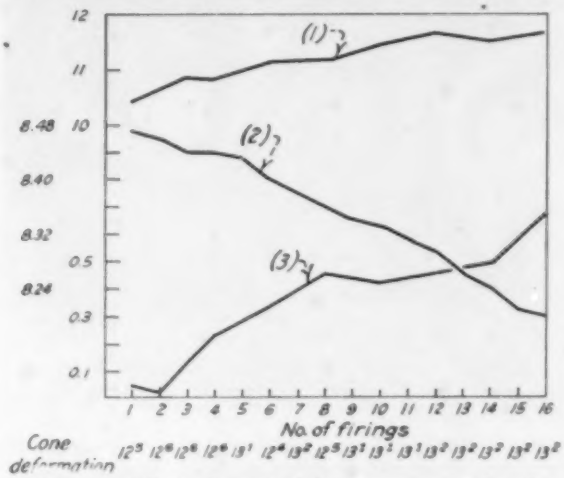


FIG. 3.—Effect of repeated firings on properties of a vitreous china body (slower firing); *curves:* (1) flexural strength × 10^3; (2) firing shrinkage (%); (3) absorption (%).

A comparison of the data given on Figs. 2 and 3 shows the same trends although there is some irregularity. The firing-shrinkage value steadily decreased in both sets of data which indicates a continuous but small expansion of the body with repeated firings. After 12 firings, the expansion was 0.13% over the initial fired value on the faster firing, shown in Fig. 2, in contrast with 0.17% for the slower firing, shown in Fig. 3. The strength increase in the 12th cycle over the initial first fired value was 15.6% for the faster firing compared to 11.6% for the slower firing; the absorption was similar. For practical purposes, the changes noted here on refiring this body once or twice are insignificant. In a few cases, blistering occurred in the interval between 12 and 16 firings.

III. Microstructure Versus Thermal History

Figures 4 and 5 show photomicrographs of thin sections of the vitreous china body fired at different rates. A faster firing rate and a higher temperature (muffle kiln, 37.2 hr., max. temp., 2300°F.), were used in the first treatment, whereas the second treatment used a slower rate of firing and a lower temperature at a relatively prolonged soaking period (multiburner kiln, 50.4 hr., max. temp., 2275°F.).

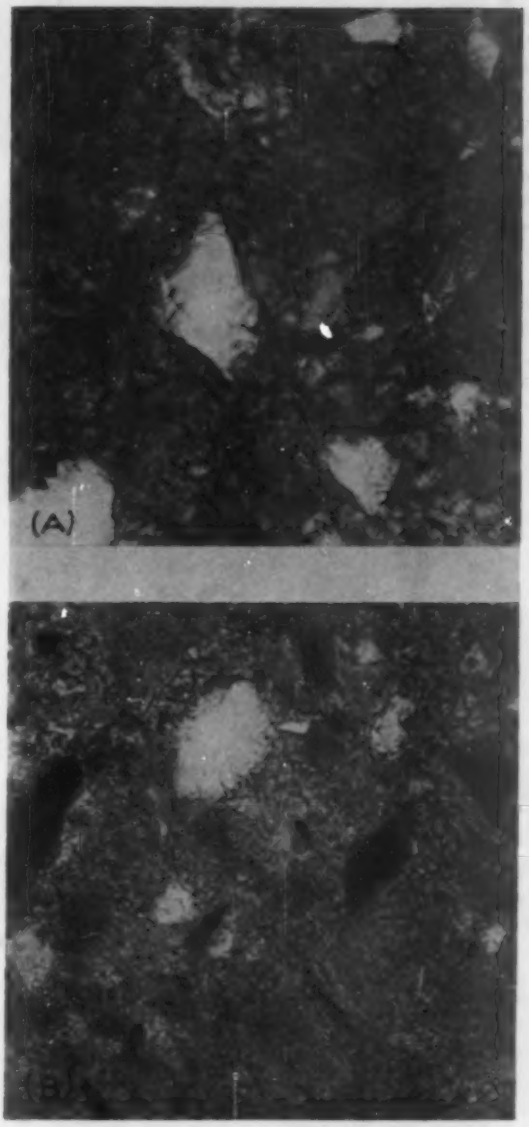


FIG. 4.—Microstructure of vitreous china body (475 ×).

The body shown in Fig. 4(*A*) was fired at the faster rate and higher temperature (on the top deck of the car), and under these conditions, the crystallizing tendencies were lessened. Figure 4(*B*) shows the same body fired on the bottom deck of the same car. To compare these microstructures with those fired at the slower rate and lower temperature, Fig. 5(*A*) represents the top deck of the car and Fig. 5(*B*), the bottom deck position. The mullite crystals are more fully developed, particularly the specimen in Fig. 5(*A*). A different structure develops when the specimens are fired in varying lengths of time to the same cone temperature as has been previously shown. The shorter firing time and the higher temperature permit less quartz solution and mullite development than when

a longer firing time and a lower temperature are used. The importance of the time factor on solution and crystalline development has been repeatedly noted. The data obtained in this study show that the higher temperature-faster firing method gave higher strength although this increase in general was not marked. The effect of the cooling rate on the strength cannot be overlooked in drawing conclusions as to the relation of structure to strength; a structure with large mullite needles probably would lower the resistance to fatiguing.

Figure 6 shows the microstructure of the vitreous china body after 16 firing cycles through a multiburner kiln (see section II on repeated firings). The microstructure indicates progressive solution and also a well-defined crystalline development.

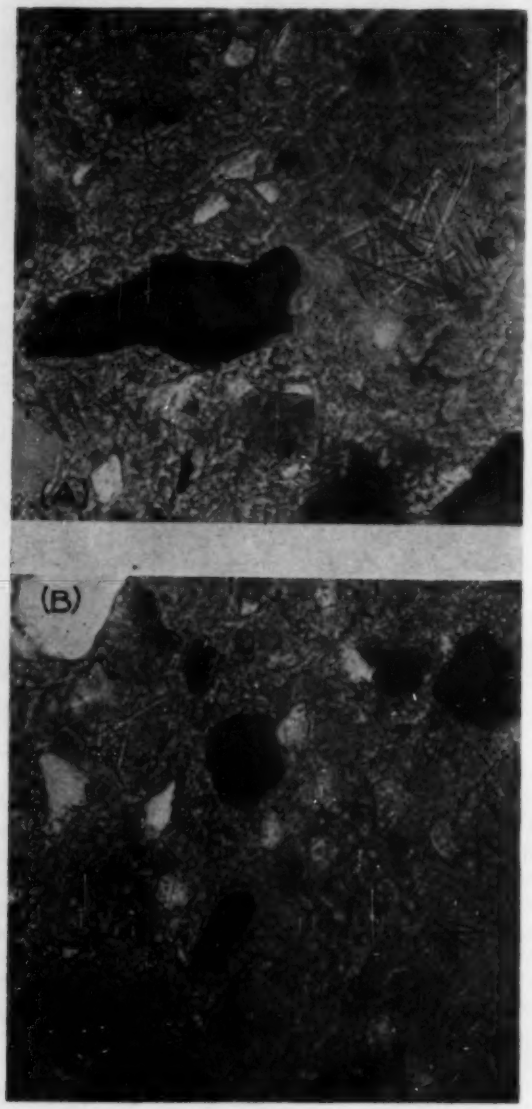


FIG. 5.—Microstructure of vitreous china body (slower firing, 475 ×).

IV. Thermal Expansion Versus Thermal History

Many data have shown that small differences in thermal history may have a marked effect on thermal expansion. Changes in this coefficient in the range of 5×10^{-6} to 6×10^{-6} have been observed in some electrical-porcelain body compositions when extreme variations in the firing schedule occurred.[1]

FIG. 6.—Microstructure of vitreous china body after 16 repeated firings (475 ×).

The thermal expansion of the body is essentially the expansion of the glass-phase solution and the characteristics of the undissolved constituents. The differences in expansion that were noted with small differences in thermal history have a ready explanation in the extent of quartz solution. Free flint has a relatively great expansion whereas dissolved flint tends to decrease the expansion characteristics of the glassy phase. Various body ingredients may have different effects on the expansion in the different firing treatments, depending on the solubility characteristics. The coefficient of thermal expansion of a porcelain body seems to be closely related to small changes in the composition of the glass phase,[1] and a determining factor might be the rate of heating as the vitrification period is approached. Shelton and Meyer[2] studied the effect of temperature rise on the reactivity of the glass phase at vitrification. Within certain limits, the low values were obtained with the more rapid rates of temperature rise and the higher values with the lower rates.

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[1] E. H. Fritz and H. C. Harrison, "Effect of Thermal History on Physical Properties of Electrical Porcelain," *Bull. Amer. Ceram. Soc.*, 18 [11] 420–21 (1939).

[2] G. R. Shelton and W. W. Meyer, "Nature of Glass Phase in Heated Clay Materials: II, Effect of Rate of Heating on Glass Phase and Physical Properties of Whiteware Bodies," *Jour. Amer. Ceram. Soc.*, 21 [11] 371–85 (1938).

The physical properties of glasses (expansion, strength, and elasticity) and, consequently, the glassy phase in a body, are known to be affected by the firing and the cooling rates. Weyl[3] states that glasses attain a degree of homogeneity in the molten state so that prolonged heating at these temperatures does not affect their properties materially unless composition changes are effected through volatilization or unless there is attack on the refractories. The rate of cooling, however, has considerable influence on the properties of glasses produced. Chilled glasses are known to have higher coefficients of expansion than annealed glasses. When a Pyrex-brand glass was heated at temperatures between 450° and 750°C., its mean linear expansivity between 20° and 200°C. changed more than 10%.[4]

The variation in the thermal expansion of a vitreous body fired on various car decks through a muffle kiln in 37.2 hours is shown in Fig. 7. The National Bureau of Standards type of extensiometer and a heating rate of 100°C. per hour were used. Expansion rods were fired in similar positions on the various decks of a car with a cone plaque next to each specimen. In the four top decks, the maximum difference in cone temperature was 3 o'clock; the top deck, cone 13[4]; and the 4th top deck, cone 13[2]. The second and third top decks showed intermediate cone-deformation and thermal-expansion values. The thermal-expansion values of this body from cones 12[2] to 13[5] decreased progressively as the temperature was raised. This decrease in thermal expansion may be related to the increasing quartz solution in the glassy phase. In these and other data obtained on this vitreous body, the higher firing caused less change at the quartz inversion temperature. Further data were obtained with the improved interferometric procedure[5]; these data are shown in Fig. 8 for the vitreous body fired to cone 12[1] and cone 13[2] in 37 hours. This body, as in all of the previous cases, showed a lower thermal expansion at the higher firing temperature.

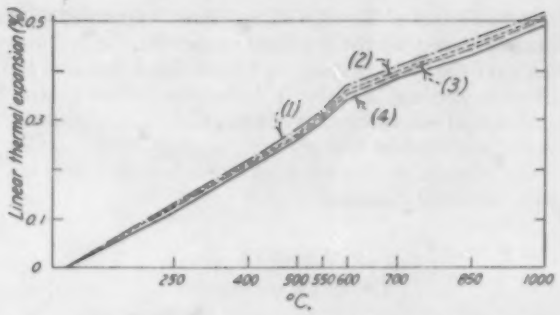

FIG. 7.—Thermal expansion of vitreous china body; *curves:* (1) 5th top deck, cone 12[2], (2) 3d top deck, cone 13[2], (3) 2d top deck, cone 13[4], (4) top deck cone 13[5].

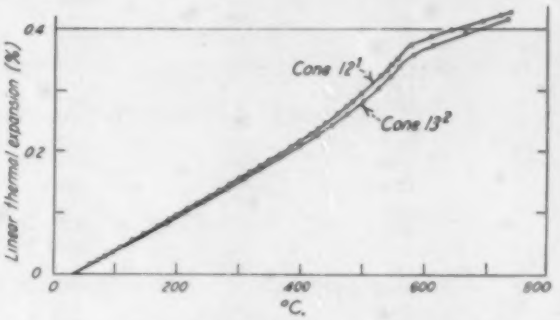

FIG. 8.—Thermal expansion of vitreous china body.

V. Effect of Thermal History on Glaze Condition

The ring specimens that were used had the same glaze application and were placed in 45 different positions in a kiln car and were single fired. The results of the test are shown in Table VIII.

The rings fired on the four top decks developed similar glaze compression; that of the rings fired on the bottom (5th top) deck was definitely lower. The thermal expansion of the vitreous body was higher for the lower cone temperature than when it was fired on the upper decks to higher cone temperatures. From the body thermal dilatation alone, a higher glaze compression would be expected for the lower temperature firing. The glaze, however, as well as the body, had lower expansion at the higher firing. This was shown experimentally by measurements of a number of glazes taken from ware which was fired to cones 12[1] and 13[2]. The greater body solution by the glaze at the higher temperature provides for lowering of the glaze expansion as well as for more volatilization of certain glaze ingredients.

Considerable data were taken to show additional effects of thermal history (different firing schedules and cone temperatures) on the stress condition of various glazes on the vitreous body (see Table IX).

The marked effect of thermal history on the glaze stress condition is further shown, and the lower cone temperature again gave the lowest glaze compression. As previously noted, these results do not agree with the individual body thermal-expansion data. In consid-

TABLE VIII

RING TEST SPECIMENS FIRED IN FORTY-FIVE POSITIONS*

Firing position	Top deck	2d top	3d top	4th top	5th top	Avg.
1	0.110	0.094	0.098	0.064	0.074	0.088
2	.086	.084	.088	.092	.068	.084
3	.104	.088	.076	.102	.046	.083
4	.094	.094	.092	.080	.070	.086
5	.094	.086	.090	.092	.060	.084
6	.090	.100	.092	.076	.068	.085
7	.082	.098	.094	.104	.054	.086
8	.104	.098	.094	.098	.064	.092
9	.082	.090	.084	.100	.070	.085
Avg.	.094	.092	.090	.090	.064	

* All of the values are in mm. minus (−) compression.

[3] W. A. Weyl, "Thermal History of Glassy Phase and Its Effect on Physical Properties," *Bull. Amer. Ceram. Soc.*, **18** [11] 416–19 (1939).

[4] J. B. Saunders and A. Q. Tool, "Effect of Heat-Treatment on Expansivity of a Pyrex-Brand Glass," *Bur. Standards Jour. Research*, **11** [6] 799–810 (1933); R.P. 626; *Ceram. Abs.*, **13** [3] 56 (1934).

[5] J. B. Saunders, "Improved Interferometric Procedure with Application to Expansion Measurements," *Jour. Nat. Bur. Standards*, **23** [1] 179–95 (1939); R.P. 1227; *Ceram. Abs.*, **18** [11] 306 (1939).

ering the effect of the variation of body expansion with thermal history on the resultant properties, the assumption that the glaze is stable or has similar expansion for different thermal history is fallacious. It is evident from actual measurements of the glaze (taken from the ware) that thermal history and its effect on the extent of the glaze-body reaction play an important role in the glaze thermal expansion.

TABLE IX

GLAZE COMPRESSION*

Glaze No.	Muffle kiln (37.2 hr., cone 13[1])	Multiburner kiln (42 hr., cone 12[2])	Multiburner kiln (42 hr., cone 11[2])
1	0.076	0.080	0.055
2	.098	.107	.075
3	.071	.057	.047
4	.090	.086	.080
5	.125	.094	.064
6	.110	.093	.072
7	.110	.078	.070
8	.128	.094	.082
9	.132	.087	.078
10	.146	.108	.072
11	.120	.068	.064
12	.126	.070	.068
13	.138	.079	.060
14	.130	.077	.072
15	.119	.072	.065
16	.127	.074	.070
17	.141	.087	.082
18	.140	.093	.068
19	.055	.052	.038
20	.181	.177	.101

* Values in mm. minus (−) compression; avg. of 3 rings.

Inasmuch as the glaze stress condition has been shown to be affected by the thermal treatment, the various properties, such as mechanical strength and thermal endurance of the glazed specimen, which depend on the stress condition, are similarly affected. As the compressive stress in the glaze is progressively higher, these properties are enhanced.

Among the possible factors which enter into an explanation of the effect of firing rates and temperatures on the stress condition are (1) physical changes of the body in expansion, elastic, and strength properties, (2) changes in similar properties of the glaze, and (3) the viscosity-temperature characteristics of the glaze and changes in these properties as a result of body-glaze interaction. Some of these conditions offset one another, and an optimum treatment probably exists for any particular glaze and body which would give the most desirable stress condition possible for that glaze and body.

The variation in glaze stress condition, with relatively small differences in thermal history, emphasizes the necessity in experimental work of the use of a standard body and glaze which is fired along with the experimental body or experimental glaze. The comparative data thus attained provide a relative estimate and to a large extent, eliminate the question of how much thermal history differences influence these data.

Additional References

1. A. S. Watts, "Data on Influence of Firing Time on Properties of Some Whiteware Bodies," *Jour. Amer. Ceram. Soc.*, **19** [6] 175–76 (1936).

2 (*a*). J. T. Littleton, "Effect of Heat-Treatment on Physical Properties of Glass," *Bull. Amer. Ceram. Soc.*, **15** [9] 306–11 (1936); (*b*) "Physical Processes Occurring in Melting and Cooling of Glass," *Jour. Amer. Ceram. Soc.*, **17** [3] 43–49 (1934).

3. R. F. Geller, "Effect of Repeated Heatings on Mechanical Strength of High-Tension Insulator Porcelains," *Bull. Amer. Ceram. Soc.*, **12** [1] 18–25 (1933).

4. Anon., "Physical Properties of Porcelain," *Ceram. Ind.*, **8** [5] 543 (1927).

5. A. A. Klein, "Time and Temperature of Burning as Factors Influencing the Constitution of Microstructure of a Porcelain Body," *Jour. Amer. Ceram. Soc.*, **3** [12] 978–83 (1920).

6. A. B. Peck, "Effect of Time and Temperature on Microstructure of Porcelain," *ibid.*, **2** [3] 175–94 (1919).

7. H. Köhl, "Thermal Expansion and Some Other Physical Properties of Fine Porcelain as Affected by Composition and Firing Temperature," *Ber. deut. keram. Ges.*, **3** [6] 303–44 (1922); *Ceram. Abs.*, **5** [2] 60 (1926).

8. J. T. Robson, "Rapid Firing of Semiporcelain," *Jour. Amer. Ceram. Soc.*, **16** [7] 296–98 (1933).

9. T. H. Tives, "Ceramic Firing," *Keram. Rundschau*, **42** [29] 353–57; [31] 383–85 (1934); *Ceram. Abs.*, **14** [2] 46 (1935).

10. J. B. Austin, "Physics and Chemistry of Firing Ceramic Ware," *Bull. Amer. Ceram. Soc.*, **14** [5] 157–65 (1935).

11. Symposium on "Ceramic Ware Firing," *ibid.*, **14** [8] 251–59 (1935).

12. Symposium on "Importance of Thermal History," *ibid.*, **18** [11] 411–21 (1939).

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January 20, 1941	2007	262	27	594	220	3110
March 10, 1941	2023	257	26	620	220	3146
April 21, 1941	1794	247	47	563	220	2871
May 21, 1941	1839	249	47	580	220	2935
June 21, 1941	1875	249	45	584	220	2973
July 21, 1941	1898	251	46	587	220	3002
August 21, 1941	1935	253	45	590	220	3043
September 21, 1941	1963	254	43	592	220	3072
October 21, 1941	1980	254	43	613	220	3110
November 21, 1941	2013	256	39	610	220	3138
December 21, 1941	2030	258	38	609	220	3155

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PROPERTIES OF WARE VERSUS THERMAL HISTORY: II, TESTS ON SEMIVITREOUS CHINA BODIES AND WARE*

By J. H. Koenig

Abstract

The properties of semivitreous bodies and ware, which were given different thermal treatments, are compared. The tests include flexural strength, shrinkage, absorption, elasticity, moisture, and thermal expansion. The resistance to crazing vs. the bisque thermal history is correlated with (1) the moisture and thermal expansion of the two bodies studied, (2) actual crazing tests on ware made from these bodies, and (3) glaze fit tests. The variation in glaze texture, hardness, and stress condition for different glost-firing treatment was studied.

I. Procedure and Test Data

Two semivitreous bodies were studied; one of these (No. 3) was a talc-pyrophyllite body. Plates were jiggered from each body, using the same tool setting, and other specimens were prepared from the same body samples.

The specimens were fired on different car decks through a Dressler multiburner direct-fire tunnel kiln on cone 8 and cone 9 firings (same schedule). Figure 1 shows a representative cone deformation for these firings. The specimens and bungs of plates were placed in the same relative area of each deck. The glost-firing treatment was held as similar as possible. The specimens were glost fired in saggers in the same relative position through a circular glost kiln to cone 6^1 in 36 hours. The deformation in the various saggers in which specimens were fired was seven saggers to cone 6^1 and four saggers to cone 6^2. Because the specimens were purposely distributed among the different saggers, the glost thermal history is considered to be fairly uniform. The same dinnerware glaze (cone 5) was used on all of the glazed specimens.

Fig. 1.—Cone deformation on various decks; (1) top deck; (2) 2d top deck; (3) 3d top deck; (4) 4th top deck; (5) 5th top deck (bottom deck).

(1) Specimens Fired in Different Car Deck Positions to Cones 8 and 9

Tables I and II, which present the individual data for the specimens and ware on the specific car decks, show the effect on these properties of slight variations in heat-treatment.

Figure 2 shows the variations in the properties of bodies and ware compared to the position on the car deck or the height in the kiln. The cone deformations near the specimens in their firing positions are given at the bottom of Fig. 2. Body No. 2 varied in flexural strength from 6400 lb. per sq. in. on the top deck fired at cone 10^1 to 5600 lb. per sq. in. on the 5th top deck fired at cone 9^3. The elastic moduli were generally related to the strength, that is, the stronger the mechanical bond, the more difficult it was to distort under load. The variations in firing shrinkage and in bisque rim warpage are shown as well as the resistance of the bisque to mechanical abuse and the

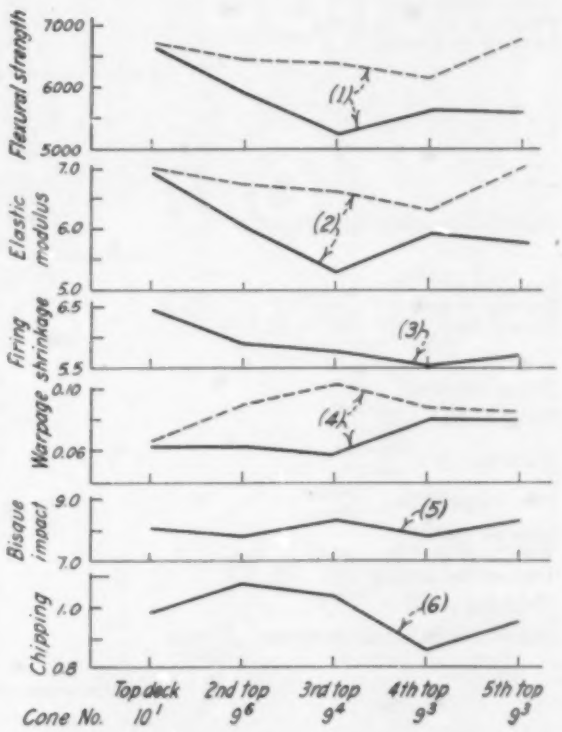

Fig. 2.—Variation in properties vs. car deck position; solid lines represent body No. 2; dotted lines represent body No. 3; *curves:* (1) flexural strength; (2) elastic modulus; (3) firing shrinkage; (4) rim warpage; (5) impact strength; (6) chipping strength.

* Presented at the Forty-First Annual Meeting, The American Ceramic Society, Chicago, Ill., April 17, 1939 (Symposium on The Importance of Thermal History). Received August 18, 1941.

chipping and impact values for the specimens fired in the different positions. These variations in properties with improved firing conditions probably indicate the greater variation formerly noticed in such properties for different kiln positions when poorer firing conditions were attained.

(2) Bisque Absorption vs. Positions in Bung and Car Deck

Table III shows the bisque absorption of the plates versus the firing position of the bisque in the bung.

Figure 3 shows absorption data on bisque ware which was made from the two semivitreous bodies. The average absorption of the top, center, and bottom plates from a number of bungs (10 plates to a bung) for the two firings are shown at the top of Fig. 3. These bungs were in the same relative position on each deck. The top plates have the lowest absorption, and those in the center of the bung the highest absorption. The variation in absorption of the bisque ware from the different car decks is shown at the bottom of Fig. 3. The centers of bisque ware in all of the tests were more porous than the rim or outer portion. The plates in the bungs that were placed in the center of the car show greater absorption than those (comparative position in bung) placed on the outside of the car. These results have been correlated by other data.

Figure 4 shows data on rim warpage and plate size

TABLE I

EFFECT OF VARIATIONS IN HEAT-TREATMENT ON WARE ON SPECIFIC CAR DECKS

Car deck	Top deck	2d top	3d top	4th top	5th top
Semivitreous body No. 2 on cone 8 firing					
Cone deformation	9^2	9^4	9^2	9^2	8^2
Flexural strength (lb./sq. in.)	5717	5809	5328	5467	5339
Elastic modulus (lb./sq. in. × 10^6)	5.75	6.31	5.35	5.69	5.94
Absorption (%) test pieces	8.15	7.31	7.63	7.89	8.31
Absorption (%) bisque	8.58	8.02	8.92	8.50	9.02
Firing shrinkage (%)	5.69	5.61	5.58	5.01	5.36
Weight (gm.) bisque	412.0	409.9	396.3	412.7	408.7
Weight (gm.) glost	425.8	429.5	410.7	428.9	423.4
Plate size (in.) bisque	9.20	9.20	9.24	9.24	9.24
Plate size (in.) glost	9.13	9.18	9.19	9.20	9.21
Rim warpage (in.) bisque	0.078	0.085	0.056	0.055	0.056
Rim warpage (in.) glost	0.099	0.092	0.082	0.098	0.078
Loss on biscuit (%)	7.25	7.85	7.39	7.36	7.26
Weight of fired film (gm.)	17.47	17.97	17.23	17.43	17.37
Increase on glazing (%)	4.28	4.37	4.38	4.24	4.28
Moisture expansion (%) at 150 lb./sq. in.					
Hr. 1	0.048			0.041	0.042
Hr. 2	.093			.086	.080
Hr. 3	.121			.101	.099
Hr. 4	.123			.109	.104
Hr. 5	.130			.112	.110
Glaze compression (mm., ring test)	(−) 0.166	(−) 0.146	(−) 0.134	(−) 0.142	(−) 0.154
Semivitreous body No. 2 on cone 9 firing					
Cone deformation	9^6, 10^1	9^6	9^4	9^3	9^3
Flexural strength (lb./sq. in.)	6646	5926	5263	5695	5633
Elastic modulus (lb./sq. in. × 10^6)	6.91	6.01	5.30	5.92	5.76
Absorption (%) test pieces	5.91	6.67	7.75	7.54	7.28
Absorption (%) bisque	6.69	6.66	8.05	7.69	7.44
Firing shrinkage (%)	6.47	5.89	5.78	5.54	5.70
Weight (gm.) bisque	407.2	410.4	415.7	414.3	412.2
Weight (gm.) glost	424.6	428.7	433.7	436.6	430.9
Plate size (in.) bisque	9.15	9.18	9.22	9.21	9.22
Plate size (in.) glost	9.12	9.17	9.19	9.23	9.20
Rim warpage (in.) bisque	0.063	0.068	0.057	0.080	0.081
Rim warpage (in.) glost	0.086	0.086	0.070	0.085	0.079
Loss on biscuit (%)	7.46	7.52	7.43	7.64	7.93
Weight of fired film (gm.)	18.16	18.22	18.32	18.48	17.96
Increase on glazing (%)	4.47	4.44	4.41	4.42	4.35
Chipping (in.-lb.) bisque	0.97	1.07	1.03	0.85	0.94
Chipping (in.-lb.) glost	1.38	1.04	1.02	0.84	0.88
Impact (in.-lb./in. of thickness) bisque	8.03	7.77	8.31	7.79	8.32
Impact (in.-lb./in. of thickness) glost	6.50	5.65	5.38	6.17	6.23
Moisture expansion (%) at 150 lb./sq. in.					
Hr. 1				0.036	0.038
Hr. 2				.080	.076
Hr. 3				.084	.082
Hr. 4				.098	.094
Hr. 5				.102	.096
Glaze compression (mm., ring test)	(−) 0.158	(−) 0.142	(−) 0.114	(−) 0.129	(−) 0.141

for several hundred specimens for various firing positions on the car deck; at the bottom are the results versus the position of the plate in the bung. The size of the plate varies slightly with the position in the bung.

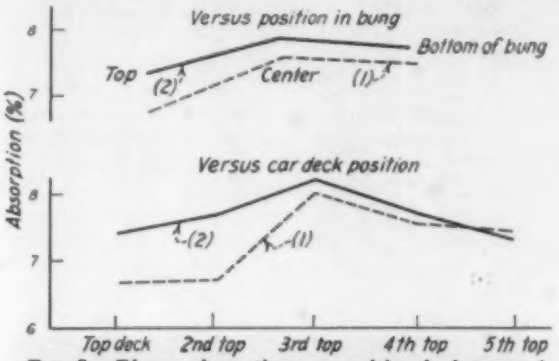

FIG. 3.—Bisque absorption vs. position in bung and car deck; *curves:* (1) body No. 2, cone 9 firing; (2) body No. 3, cone 8 firing.

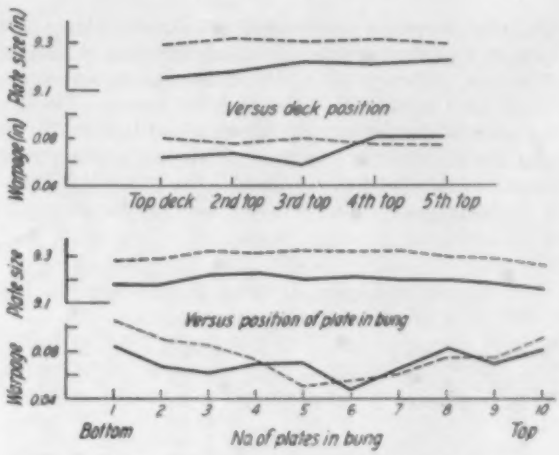

FIG. 4.—Bisque rim warpage and plate size for various firing positions; solid lines represent body No. 2, cone 9 firing; broken lines represent body No. 3, cone 8 firing.

TABLE II

EFFECT OF VARIATIONS IN HEAT-TREATMENT ON WARE ON SPECIFIC CAR DECKS

Semivitreous body No. 3 on cone 8 firing

Car deck	Top deck	2d top	3d top	4th top	5th top
Cone deformation	9^2	9^4	9^2	9^2	8^2
Flexural strength (lb./sq. in.)	5888	6059	6454	6113	6161
Elastic modulus (lb./sq. in. × 10^6)	6.31	6.40	6.62	6.32	6.50
Absorption (%) test pieces	6.39	6.22	6.10	6.33	6.29
Absorption (%) bisque	7.42	7.63	8.23	7.56	7.35
Firing shrinkage (%)	5.53	5.47	5.67	5.73	5.63
Weight (gm.) bisque	379.4	375.9	377.3	380.7	363.5
Weight (gm.) glost	398.4	393.3	396.9	399.6	381.0
Plate size (in.) bisque	9.29	9.32	9.31	9.32	9.30
Plate size (in.) glost	9.28	9.30	9.32	9.31	9.29
Rim warpage (in.) bisque	0.079	0.075	0.079	0.074	0.073
Rim warpage (in.) glost	0.073	0.070	0.083	0.079	0.087
Loss on biscuit (%)	11.19	10.47	9.99	10.28	9.77
Weight of fired film (gm.)	18.31	18.55	18.88	18.49	18.89
Increase on glazing (%)	4.82	4.95	5.00	4.86	5.22
Chipping (in.-lb.) bisque	0.72	0.86	0.82	0.75	0.61
Chipping (in.-lb.) glost	0.64	0.62	0.64	0.46	0.38
Impact (in.-lb./in. of thickness) bisque	7.67	7.41	7.29	7.87	7.10
Impact (in.-lb./in. of thickness) glost	6.23	6.12	6.32	5.32	5.68

Moisture expansion (%) at 150 lb./sq. in.

Hr.				
1	0.016		0.019	
2	.029		.032	
3	.033		.034	
4	.039		.041	
5	.041		.043	

Semivitreous body No. 3 on cone 9 firing

Cone deformation	9^8, 10^1	9^6	9^6	9^3	9^3
Flexural strength (lb./sq. in.)	6693	6462	6429	6202	6850
Elastic modulus (lb./sq. in. × 10^6)	6.97	6.72	6.60	6.29	6.99
Absorption (%)	4.99	5.41	5.35	5.26	4.75
Plate size (in.) bisque	9.28	9.28	9.27	9.26	9.25
Plate size (in.) glost	9.28	9.31	9.29	9.28	9.25
Rim warpage (in.) bisque	0.063	0.090	0.116	0.087	0.083
Rim warpage (in.) glost	0.101	0.079	0.090	0.086	0.059

Moisture expansion (%) at 150 lb./sq. in.

Hr.				
1			0.004	0.005
2			.012	.010
3			.014	.016
4			.018	.023
5			.024	.029

The top plates are the smallest; the center plates, the largest; and the bottom plates, intermediate in outside diameter, although all of these differences are small. These data agree with the absorption values. The rim warpage is also greater for the top and bottom plates and less for the center plates. This fact appears to be more than a coincidence in spite of the role which forming and drying of the ware may have on this property.

TABLE III

BISQUE ABSORPTION (%) VS. BUNG POSITION

	Bung position		
Body No. 2, cone 9	Top	Middle	Bottom
Top deck	5.70	7.13	7.24
2d top deck	5.83	6.81	7.34
3d " "	7.89	8.10	8.10
4th " "	7.61	7.86	7.60
5th " "	6.89	7.99	7.45
Avg.	6.78	7.58	7.54
Body No. 3, cone 8			
Top deck	6.54	7.80	7.92
2d top deck	7.72	8.01	7.16
3d " "	8.16	8.26	8.26
4th " "	7.36	7.74	7.57
5th " "	6.98	7.42	7.65
Avg.	7.35	7.85	7.71

II. Thermal Expansion vs. Thermal History

Thermal-expansion measurements were made on rod specimens with the National Bureau of Standards type of dilatometer. All of the specimens were fired in the same relative position in the kiln on both firings (Table IV).

The higher firing decreased the thermal expansion of both bodies (Fig. 5). Body No. 2 had more of the inversion "kick" and more falling off above this point in the lower firing treatment than when it was fired at one cone higher; at both cone temperatures, this reaction was more manifest in body No. 3, which had less initial free flint.

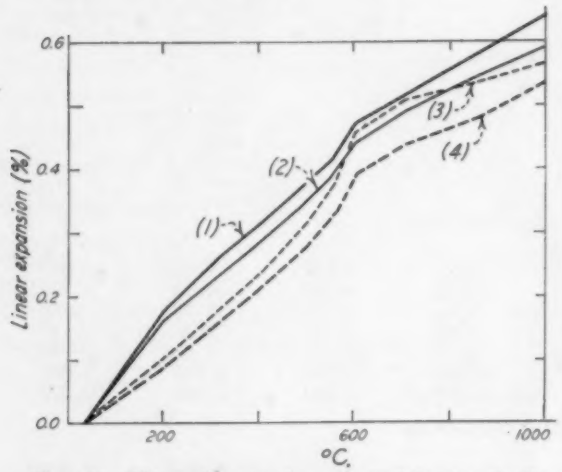

FIG. 5.—Thermal expansion of semivitreous bodies Nos. 2 and 3 at cone 9^1 and cone 9^4; heavy solid and heavy broken lines represent normal firing of bodies; *curves:* (1) body No. 3, cone 9^1; (2) body No. 3, cone 9^4; (3) body No. 2, cone 9^1; (4) body No. 2, cone 9^4.

TABLE IV

THERMAL EXPANSION OF SEMIVITREOUS BODIES

Body No.	2	2	3	3
Cone deformation	9^1	9^4	9^1	9^4
Temp. (°C.)	Linear thermal expansion (%)			
30–100	0.037	0.036		
200	.099	.091	0.181	0.161
300	.166	.149	.250	.225
400	.235	.211	.311	.283
500	.318	.279	.377	.348
550	.370	.322	.413	.387
600	.457	.388	.471	.442
700	.503	.436	.515	.492
850	.537	.480	.580	.545
1000	.567	.540	.642	.595

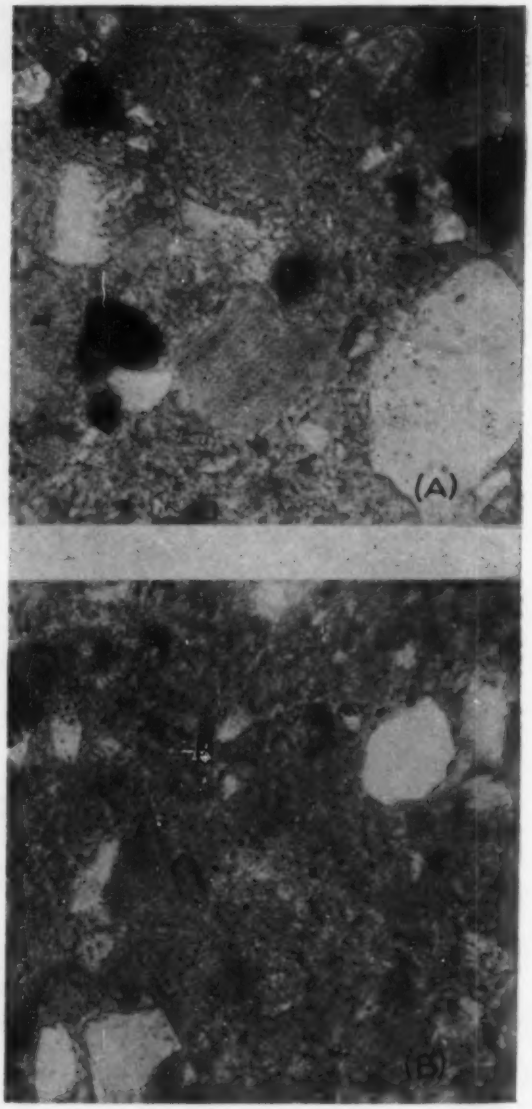

FIG. 6.—Microstructure of bodies (475 ×); *A*, body No. 2, *B*, body No. 3.

The photomicrostructure of these two bodies is shown in Fig. 6.

The large quartz grains in body No. 2 indicate that there was no solution, but the smaller grains seem to be rounded off. Pseudomorphs of feldspar grains are visible with embedded mullite needles. These mullite needles are more highly developed in one of the feldspar pseudomorphs (that is, two feldspars in the body) probably because of the difference in viscosity. Little, if any, development of mullite is noted in body No. 3.

Thermal-expansion measurements of a number of commercial bodies were run at intervals from 6 months to one year, and some of these data are shown in Fig. 7. A semivitreous body from plant A showed the greatest variation in this property at the test intervals; there is less variation in the data on the semivitreous body from plant B. Although variations in plant preparations may be an active factor in effecting such differences (for example, the grain size of the nonplastics), the differences in the thermal history are also important.

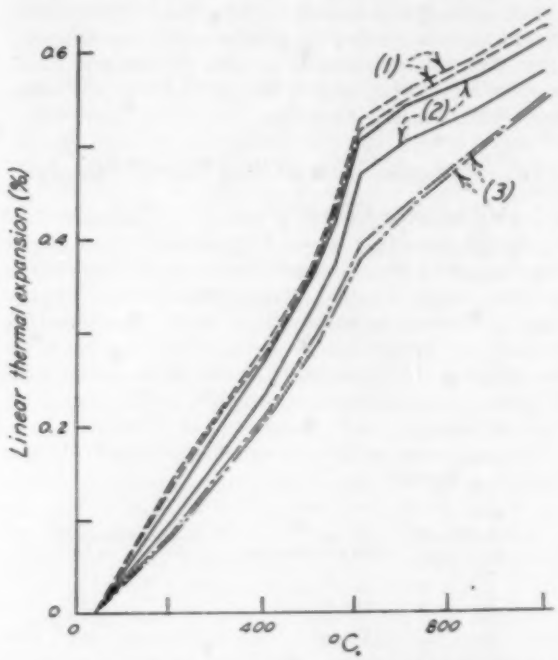

FIG. 7.—Thermal expansion of commercial bodies tested at intervals; *curves:* (1) plant B; (2) plant A; (3) plant C.

A noticeable difference in the body from plant A is assigned to a known change in the bisque firing; plant C is a hotel china body.

III. Resistance to Crazing vs. Bisque Thermal History

The moisture-expansion data for bodies Nos. 2 and 3 are given in Tables I and II. The specimens (5-in. rods), which were measured after each autoclave treatment, were subjected to 150 lb. of steam pressure for one hour and were given one hour to build and to release the pressure uniformly. An Ames dial, which could be read with ease to $^1/_{10.000}$ inch, was used to measure the moisture expansion. The porosity and moisture expansion were reduced at the higher cone firings as was expected. These effects are shown in Fig. 8.

The same schedule was used to measure the resistance to crazing in the autoclave as for the moisture-expansion measurements. The test was repeated on the plates to initial failure, and the factor is an average of the total number of cycles to produce failure of all the plates being tested divided by the number of plates. Factors expressing resistance to thermal quenching were calculated by the same method. The thermal-shock test consisted of quenching from an oven temperature of 175°C. to water at 25°C. These data are given in Table V.

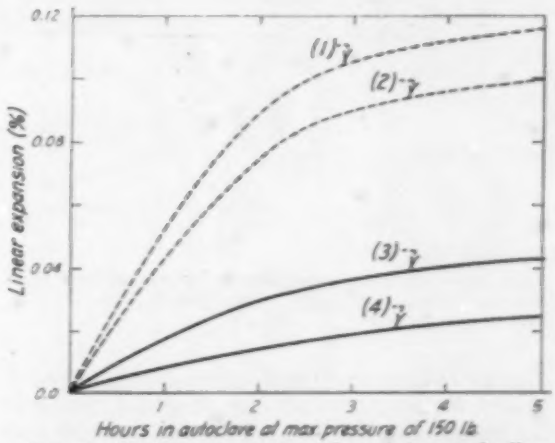

FIG. 8.—Moisture expansion of semivitreous bodies; *curves:* (1) body No. 2, cone 8[1]; (2) body No. 2, cone 9[1]; (3) body No. 3, cone 8[2]; (4) body No. 3, cone 9[2].

TABLE V

GLAZE STRESS CONDITION VS. CRAZING

	Crazing factors		Moisture expansion (%) (5 cycles, 1 hr. /150 lb.)	Linear thermal expansion (%)		Glaze compression (mm.)	
	Autoclave test (1 hr./150 lb.)	Thermal quenching (175°–25°C.)		30°–600°C.	30°–1000°C.	Ring test	Tuning-fork test*
Body No. 2							
Cone 9	2.9	5.2	0.099	0.388	0.540	(–) 0.114	(–) 0.99
Cone 8	3.4	5.0	.111	.457	.567	(–) .134	(–) 1.26
Body No. 3							
Cone 9	8.4	8.5	.027	.442	.595	(–) .148	
Cone 8	10.3	9.4	.042	.471	.642	(–) .288	

* Softening point to room temperature.

Plates of both bodies which received the higher firing treatment had less resistance to crazing in the autoclave than the plates which were subjected to the lower firing. The absorption and moisture expansion, however, were reduced by the higher firing. This observation is explained by the glaze-fit data in Table V and also by the thermal-expansion data. The higher firing gave a lower expansion in both bodies; this fact is reflected in the glaze-fit data, in which the same glaze application and glost firing indicated a higher glaze compression on the bodies that were fired to a lower cone temperature or on those with a higher body expansion. Inasmuch as the comparison given here is for an individual body, any change in glaze expansion due to the body is relative. The effect of the initial glaze condition, therefore, is emphasized although it is also desirable to have low moisture expansion. For the same initial glaze condition, it is reasonable to suppose that the importance of low moisture expansion would be shown, but the data here indicate that differences in moisture expansion are less important than those of thermal expansion.

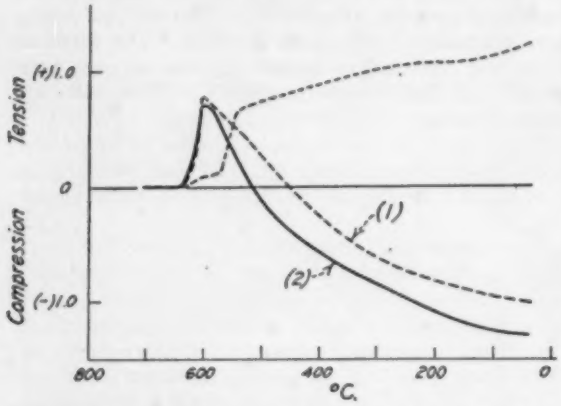

FIG. 9.—Glaze stress as shown by tuning-fork test (heating cycle); *curves:* (1) body No. 2, cone 9^6; (2) body No. 2, cone 9^1.

Tuning forks made from body No. 2 were prepared, bisque fired at cone 9^1 and cone 9^6, glazed, and glost fired as in the earlier tests. The data are plotted as deflections on Fig. 9 (plotting the deflections seemed to be as satisfactory a method as calculating in terms of stress units). These data correlate with the glaze-stress data given by the ring test. (The correlation is good for these data as well as other data which have been taken.) The tuning-fork values given in Table V show the resultant stress at room temperature (softening point to room temperature), which is the value measured in the ring test.

The two stress curves for the same glaze on body No. 2, biscuited at cone 9^1 and cone 9^6, at first show a rapid increase in tension where the glaze becomes rigid. This is above the inversion temperature where the body expansion is small; at the inversion temperature, the rapid body contraction throws the glaze over to less tension and, at lower temperatures, finally into compression. This glaze, as on the ware and with the composition change which undoubtedly occurs, has less contraction than the body. The stress is again zero at about 500°C. for the glaze on body No. 2 which was biscuited at cone 9^1 and about 450°C. for the same body, biscuited at cone 9^6.

The glaze on the body bisque fired at a lower temperature shows greater compression at all temperatures below 600°C. than the same glaze applied on the body that was bisque fired at a higher temperature. As could be predicted from the individual body thermal-expansion data in this case and as shown by the ring test, the degree of glaze compression is brought out by the tuning-fork data. The effect of the initial glaze compression plays an obviously important role in the autoclave resistance to crazing.

Figure 9 also shows another glaze glost fired on body No. 2, which was bisque fired at cone 9. When this glaze becomes rigid (obviously at a lower temperature than the cone 5 glaze), it goes into tension. There is a marked increase in tension, starting at about the quartz inversion temperature, which steadily becomes greater with decreasing temperature; at room temperature, there is considerable tension (+1.28 mm.) and also initial crazing on the ware. The ring test value was (+) 0.059 mm. in tension.

IV. Properties Versus Glost Thermal History

(1) Variation in Glaze Stress

Mellor[1] states that, through the solvent action of the glazes on the body, a better adhesion is obtained which helps to reduce crazing. To promote this solvent action, an increase in soaking time or a higher temperature of glost firing is effective. Mellor also refers to an investigation in which 60% of the ware crazed at a glost-oven temperature of 970°C., 40% crazed at 1020°C, and no crazing occurred at 1080°C.

Some glaze-stress data on ware made from body No. 2 are as follows:

Glost firing (hr.)	Cone deformation	Compression (mm., ring test)
72	6^8	(−) 0.147
72	6^8	(−) .140
36	6^1	(−) .114
36	4^8	(−) .022

The longer and higher glost fire is beneficial to the amount of glaze compression and, concurrently, to the crazing resistance.

(2) Variation in Glaze Texture

The glaze microtexture of various specimens of bodies Nos. 2 and 3, having the same glaze applied and fired to cone 8 and cone 9, was examined using dark-field illumination; specimens that were bisque fired on each car deck, which received the same glost treat-

[1] J. W. Mellor, "Crazing and Peeling of Glazes," *Trans. Ceram. Soc.* [England], **34** [1] 1–112 (1935); *Ceram. Abs.*, **14** [9] 233 (1935).

ment, were also included. The glaze in all cases was remarkably free from defects so that no comparison could be made. A double-frit glaze was used, and the lead frit was lead bisilicate.

The variations in glaze texture with different glost thermal treatment were observed. Two glazes, each made of the same end formula but differing in the distribution of their composition, received four different commercial glost firings. The bisque ware samples of the respective plants were also employed so that another variable was present. In laboratory trials, a difference was noted in the glaze application for the same glaze fired on different semivitreous bodies (with other conditions identical). This difference resulted from different chemical action. In some commercial glazes, small differences in glost temperature from the normal will not be reflected in the microtexture; in others, however, with all conditions identical, considerable differences occur for small departures from the normal treatment.

A further study of the effect of body solution on glaze development and freedom from defects was made. Experimental glazes were applied over a bisque vitreous china body (cone 13), a bisque semivitreous body (cone 9), and a green low-temperature body. These bodies were glost fired and single fired, respectively, at cone 5. The experimental glazes were a series of glazes of increasing silica content. The entire series developed well on the low-temperature body, single fired at cone 5 (this body is vitreous at cone 3). Only the lower silica-content glazes were good on the vitreous china body, and all of the glazes were defective and immature on the semivitreous body. The influence of the body on the glaze development is marked.

(3) Variation of Glaze Hardness

The microcharacter was used for the glaze-hardness tests. Microhardness numbers are directly proportional to resistance to scratching and therefore in reciprocal relation to the scratch width which is measured. The glaze microhardness was determined on 250 glost plates made from the semivitreous bodies, Nos. 2 and 3, which were bisque fired at cone 8 and cone 9; these plates were sprayed at the same time. The average fired film on 7-in. plates was 18.43 gm., and the coefficient of variation was 1.5%. The glaze-thickness factor and its unquestionably great effect on many properties is minimized in these tests. The bisque plates, taken from the same relative position in the bisque firing, received the same glost fire, that is, they were placed in the same kiln position. The variation in cone temperature was less than 1 o'clock in 14 saggers so placed.

	Glaze microhardness No.	
	Body No. 2	Body No. 3
Cone 8	1385	1403
Cone 9	1360	1320

For the different bisque thermal treatments, the variation in the glaze hardness was quite small; theoretically, the less porous the bisque, the less the surface available for body-glaze interaction.

In preliminary hardness tests on various glazes, the values often varied for different portions on the same piece (such as top center, bottom, and near the rim). This may in part result from the foregoing observation, inasmuch as various sections of the bisque have different porosity values; the center is generally more porous than the rim. On glost firing, moreover, the same variable in thermal history might contribute in part to such variation. Other factors are localized stress conditions and differential film thickness. The heavier glaze film is less resistant.

To provide some data showing the effect of thermal history on glaze hardness, four glazes widely different in composition were fired in the laboratory kiln at cone 3 and cone 5 down. This increase in firing temperature raised the resistance to scratching to a marked degree (Fig. 10). All of the data that were obtained in this

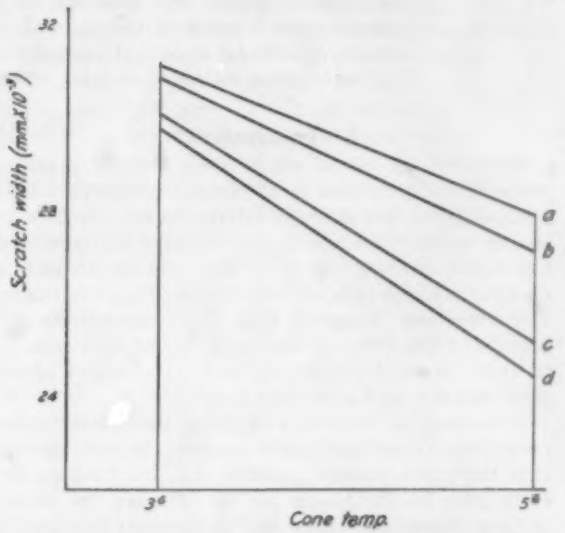

FIG. 10.—Resistance to scratch vs. glost temperature (Lyon scratch-hardness tester).

experiment have indicated an increase in glaze hardness with increasing glost temperature for the same initial composition. This may result chiefly from the augmented body solution by the glaze, although different degrees of volatilization of ingredients (such as lead) may enter into the explanation. It was shown experimentally that decreasing the lead content increased the scratch hardness.

V. Summary

From the experimental standpoint, differences in properties resulting from variations in thermal history in commercial firing are sufficient to permit misleading evidence in many comparative studies unless the materials being compared are fired together in each test.

From the industrial viewpoint, these small differences in properties with slight variations in thermal history may have little significance. They are indicative, however, of wide variations that may occur, in

which the uniformity of firing receives less attention and in which much greater differences in the firing (than those referred to here) are common. Improvement in quality resulting from progress in uniform firing is self-evident.

Acknowledgment

The writer wishes to acknowledge the advice and assistance of W. C. Bell, who made some of the glaze-fit measurements, and of L. H. Brown and G. A. Bole.

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EFFECT OF FIRING TREATMENT ON PHYSICAL PROPERTIES OF DRY-PROCESS ENAMELS*

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ABSTRACT

The relations between the firing treatment and physical properties of some commercial, antimony-bearing dry-process enamels for cast iron were studied. These properties include opacity and resistance to surface abrasion for both acid-resistant and regular enamels and acid resistance of the acid-resistant types. In contrast to wet-process enamels for sheet steel, these dry-process enamels were found to be little affected by the extreme variations in firing which might be encountered in ordinary practice.

I. Introduction

The effect of variations in firing on the physical properties is important in all ceramic products. This relationship is of particular interest in the dry-process enamel industry because of the necessity for individual treatment of each piece of ware during enameling operations which permits variations in firing treatment. The literature, however, lacks any reference to the relation of the firing treatment of dry-process enamels to their physical properties, such as abrasion resistance, opacity, and acid resistance.

In a study of the effect of firing treatment on the properties of sheet-steel cover-enamels, Tetrick[1] showed that there is a marked increase in opacity during the early part of the fusing period. During the fusing of these enamels, full gloss developed before full opacity was obtained. Hutchison[2] has presented data on the effect of firing treatment on the surface abrasion of wet-process enamels. He concluded that firing plays an important part in abrasion resistance and a slight underfiring of sheet-steel enamels is generally beneficial. His results, however, indicate that there is no marked difference between normal fired enamels and enamels which are overfired. In contrast to the sheet-steel enamels, a low-temperature, wet-process enamel for cast iron showed highest resistance to surface abrasion when normally fired although the variations caused by the firing treatment were not marked.

In order to obtain data of practical value on these relationships, several commercial, antimony-bearing dry-process enamels of both the regular and acid-resistant types were used in this investigation.

II. Firing Treatment

The enamels were milled to a fineness of 15% of residue remaining on a 100-mesh screen and were applied to circular cast-iron disks, $^{3}/_{16}$ in. thick by $4^{3}/_{4}$ in. in diameter. Each ground-coated casting was given two applications of enamel powder by the dredging process in weights comparable to commercial practice. The firing temperature for the regular enamels was 1560°F., and for the acid-resistant enamels, it was 1600°F.

TABLE I

FIRING TREATMENT OF ENAMELS

Enamel	Firing time for each application (sec.) Short fire	Normal fire	Long fire
	Regular		
A	45	60	75
B	45	60	75
C	45	60	75
	Acid resistant		
A	65	80	95
B	55	75	95
C	65	85	105
D	65	85	105

One set of castings was given a short firing that was sufficient to produce suitable gloss but not enough to eliminate the waviness of the surface. The second set was fired normally for sufficient time to give good gloss and to allow the enamel surface to level. The third set was fired longer until evidence of overfiring developed on the edges of the castings, which was not sufficient, however, to destroy the texture of the enamel surface. The length of firing time was varied with the degree of refractoriness of the enamels (see Table I). These firing periods produced results which are usually obtained under commercial conditions in about twice the time.

* Presented at the Forty-Third Annual Meeting, The American Ceramic Society, Baltimore, Md., April 1, 1941 (Enamel Division). Received May 8, 1941.

[1] J. D. Tetrick, "Opacity Development in Cover Enamels for Sheet Steel," *Jour. Amer. Ceram. Soc.*, 18 [10] 314–18 (1935).

[2] Clark Hutchison, "Effect of Various Factors on Abrasive Resistance of Porcelain Enamels," *Bull. Amer. Ceram. Soc.*, 18 [6] 202–205 (1939).

III. Enamel Properties

(*A*) *Opacity:* The Hunter multipurpose reflectometer was used to determine the reflectance. The results of these tests are shown in Table II. It is evident that the opacity of these enamels is affected only slightly by variations in firing treatment. The differences in the reflectance values for any one enamel are well within the limits of error for this method of application and are of little practical importance. It may reasonably be expected, therefore, that any variations in the covering power of commercial dry-process enamels may be attributed to other factors, such as the enamel composition, the preparation, or the weight of application.

(*B*) *Acid Resistance:* The acid resistance was determined by the P.E.I. Standard Acid-Resistance Test[3] with 10% of citric acid on the acid-resistant enamels *A*, *B*, *C*, and *D*. All of them passed the test without evidence of staining, indicating that, within the limits of the tests, the acid resistance does not vary with firing treatment.

(*C*) *Surface Abrasion Resistance:* The resistance to abrasion was determined by the P.E.I. Tentative Standard Surface Abrasion Test[4] with certain recently developed modifications in the test procedure. This test involves abrading the enamel surface by feldspar. The specimens are clamped in a suitable container in a Rotap machine, and moist feldspar and hard alloy balls are rotated over the enamel surface. The resistance to abrasion is measured by the loss of gloss of the enamel surface and is expressed as the percentage of the initial gloss which the abraded surfaces retain.

The Hunter multipurpose reflectometer was used for the gloss measurements. The instrument was calibrated according to recent revised instructions.[4] Gloss measurements were read on each specimen in each of four positions rotated 90° for successive readings. Subsequent duplicate readings required precise location of the specimen which was accomplished by the use of a special template to hold the castings.

For any one specimen, there was usually considerable range in the gloss values obtained in the four positions. The deviation was undoubtedly caused by the waviness of the enamel surface, which affects the angle of incidence and reflection of the light beam (the instrument is designed for an angle of 45°). The percentage of gloss retained, when calculated for each of the four positions on any one specimen, was generally lower for that position having the higher initial gloss reading. The surface abrasion test, therefore, cannot be considered so accurate on enamels as on polished glass plates or other materials having a plane surface.

The time of abrasion used in these tests was taken as that time required to reduce the surface gloss of the standard polished plate glass specimens by 50%. For the equipment used in these tests, the time was

[3] Standard Acid-Resistance Test, Porcelain Enamel Institute, adopted April, 1940; *Ceram. Abs.*, 19 [7] 158 (1940).

[4] Test for Resistance of Porcelain Enamels to Surface Abrasion of the Porcelain Enamel Institute. This tentative test was adopted October, 1938, with supplementary instructions issued March, 1940.

TABLE II

RELATION OF FIRING TREATMENT AND REFLECTANCE

	Reflectance (%)											
	Short fire				Normal fire				Long fire			
Enamel	1	2	3	Avg.	1	2	3	Avg.	1	2	3	Avg.
					Regular							
A	79.7	79.8	78.7	79.4	79.8	80.0	79.3	79.7	79.3	78.9	79.8	79.3
B	77.6	77.3	77.1	77.3	77.2	77.5	76.9	77.2	77.6	78.0	77.8	77.8
C	77.4	76.8	77.3	77.2	78.0	77.9	78.2	78.0	78.1	77.9	78.1	78.0
					Acid resistant							
A	82.2	82.0	82.1	82.1	83.0	82.9	82.5	82.8	82.7	82.9	82.8	82.8
B	79.6	79.9	80.9	80.1	79.4	79.9	81.1	80.1	79.2	81.0	80.9	80.4
C	78.8	78.6	79.3	78.9	79.8	79.5	79.3	79.5	80.1	79.1	80.5	79.9
D	78.4	78.5	79.5	78.8	78.9	78.6	79.5	79.0	78.2	79.2	79.0	78.8

TABLE III

RELATION OF FIRING TREATMENT AND SURFACE ABRASION RESISTANCE

	Residual gloss of fired specimens after abrasion (%)											
	Short fire				Normal fire				Long fire			
Enamel	1	2	3	Avg.	1	2	3	Avg.	1	2	3	Avg.
					Regular							
A	54.9	59.0	55.2	56.4	56.1	56.4	54.0	55.5	55.1	55.9	55.9	55.3
B	53.9	52.7	52.9	53.2	51.6	50.8	55.4	52.6	50.9	50.5	51.5	51.0
C	52.2	50.8	51.3	51.4	50.9	50.6	51.9	51.1	49.4	47.7	48.9	48.6
					Acid resistant							
A	60.2	62.3	63.6	62.0	60.3	63.3	62.1	61.9	60.1	60.7	62.3	61.0
B	53.0	52.6	51.0	52.2	50.1	52.3	52.4	51.6	51.7	48.4	50.4	50.2
C	51.0	52.2	51.3	51.5	50.6	50.7	49.0	50.1	50.3	49.2	51.0	50.2
D	60.0	61.3	58.1	59.8	59.6	59.4	60.0	59.7	57.7	59.3	58.6	58.5

determined as eleven minutes of total rotation. The results of the abrasion tests are shown in Table III. There is a slight decrease, in general, in resistance to surface abrasion with increase of firing time. This decrease is small, however, and it is probably without practical significance because the method admits similar differences on duplicate specimens given the same treatment.

The differences in resistance between various enamels, however, are significant, and the test method undoubtedly correctly evaluates abrasion resistance and approximates closely the dulling effect to which enamels on sanitary ware, table tops, and stoves are subjected in service by the use of abrasive scouring powders.

In addition to the loss of gloss, the abrasion of enamel surfaces involves other considerations. Enameled sinks, stoves, and table tops encounter materials, such as coffee and tea solutions, that cause discoloration and stain on ware which has been in service. These have no effect on the normal gloss of enamel surfaces, but they do affect enamels which have been abraded or otherwise attacked.

The authors have previously suggested that there is a relationship between abrasion and staining and that the latter might serve as a measure of abrasion. Harrison* has recommended the use of methyl violet dye for this purpose under controlled conditions after he had investigated the effects of various dyes. The conditions are as follows: The abraded specimens were washed and immersed in a 0.25% solution of methyl violet dye for 30 minutes. They were placed in a saturated solution of sodium carbonate for one minute to set the dye retained on the abraded areas. This left a film of dye over the entire specimen. The specimens were rubbed lightly with the fingers to remove the excess dye and were returned to the sodium carbonate solution for final fixing of the dye; they were then rinsed under running water and dried with a soft towel. The reflectance was determined on the Hunter reflectometer. The ratio of this reflectance to that determined on the abraded but unstained specimens was taken as the index of resistance to staining. The reflectance value was found to be inversely proportional to the absorption of the dye as determined by visual estimation of the darkness of the stain. The index of resistance to staining, however, was not always directly related to the loss of gloss as determined by the standard abrasion test method. The difficulty lay in the method of staining because the absorption of dye by specimens of the same enamel, which had the same abrasion index and had been given the same staining treatment, was not always consistent. The fact that there is a definite relation between reflectance values and visible stains indicates that the method offers possibilities if a dye can be obtained and a test procedure developed which will stain the abraded portions in proportion to the amount of abrasion. Grading the stain by visual observation or reflectance determinations would be simpler than measurements of gloss before and after abrasion.

* Private memorandum to the authors from W. N. Harrison, National Bureau of Standards.

IV. Summary

(1) This investigation of antimony-bearing dry-process enamels emphasizes their stability and the contrast to wet-process enamels for sheet steel. These dry-process enamels show no variations in opacity over a wide firing range, whereas the wet-process enamels containing moderate amounts of antimony compounds show marked changes in opacity which increases up to a certain point after which there is a leveling off and in some cases a slight decline on overfiring.

(2) The acid resistance of commercial dry-process enamels was not affected by variations in firing treatment.

(3) There was a slight decrease in resistance to surface abrasion with increase of firing, but the variations were not of practical importance. The resistance to surface abrasion varied with the individual enamels. The most resistant enamels were the acid-resistant type, although some regular enamels had better resistance than some acid-resistant enamels.

(4) The dye-stain method merits further study as means of measuring abrasion resistance.

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EFFECT OF SET OF ENAMELS ON HYDROMETER READINGS OF THE SLIP*

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Abstract

The operation in enameling that is the most difficult to control is the setting up of enamels for dipping. The difficulty occurs because there has been no practical accurate method for measuring the set of the enamel. Practical experience shows that viscosity is not an indication of the set or of the dipping weight. The method presented consists in determining the apparent specific gravity of the enamel slip with true value for the specific gravity. Calculations give a numerical value for the value of the set or yield point. The measurements are accurately reproducible, and dipping weights have been found to correlate quite well with the results given of tests in laboratory and plants.

I. Introduction

(1) Purpose and Scope of Investigation

Rosenberg and Naylor[1] have shown that an indication of the set or yield point of an enamel slip can be obtained by determining the apparent specific gravity with a hydrometer. They showed that when an enamel slip is changed by the addition of the usual agents which affect the set of enamel slips, the apparent specific gravity is lowered when the set is reduced and raised when the set is increased. The data presented here are a continuation of their work.

Table I

Additions (5-cc. Increments) of 1.5% Sodium Pyrophosphate Solution to 3000 cc. of Ground Coat

Total cc. added	Sp. gr.	Flow	Hydrometer reading	Pick-up (gm./sq. ft.)
		January 20, 1941		
0	1.591	13.5	1.816	19.2
5	1.591	13.0	1.785	15.9
10	1.591	12.9	1.750	12.6
15	1.592	12.8	1.725	10.8
20	1.592	12.8	1.700	9.6
25	1.591	12.7	1.685	8.1
30	1.585	12.7	1.660	8.4
35	1.585	12.8	1.638	6.3
40	1.585	12.7	1.620	6.6
45	1.580	12.7	1.605	6.3
		January 21, 1941		
0	1.599	13.7	1.850	18.6
45	1.591	12.8	1.630	7.5
50	1.591	12.8	1.630	7.5
55	1.585	12.8	1.625	6.9
60	1.584	12.7	1.615	6.9
65	1.591	12.7	1.615	6.6
70	1.585	12.7	1.605	6.6
75	1.585	12.6	1.605	6.3

The specific gravity, mobility, hydrometer reading, and pick-up on a weigh sheet were determined on a series of ground coat enamel slips that were varied by the addition of water and other agents to reduce the set and of set up agents to increase the set.

II. Description of Method

The specific gravity was determined by weighing a 100-cc. specific gravity bottle filled with the slip. A quick method of determining specific gravity was used occasionally by adding saturated sodium pyrophosphate solution or the solid salt to the slip and then using the hydrometer reading. When the set is entirely eliminated with sodium pyrophosphate, the hy-

Table II

Additions (200-cc. Increments) of Water to 5 Gallons of Ground Coat

Total cc. added	Sp. gr.	Flow	Hydrometer readings	Pick-up (gm./sq. ft.)
0	1.624	13.6		32
200	1.600	13.4	1.995	27.8
400	1.592	13.1	1.960	26.7
600	1.582	13.0	1.940	24.4
800	1.576	13.0	1.870	23.7
1000	1.572	12.9	1.850	21.5
1200	1.570	12.7	1.805	19.3
1400	1.569	12.6	1.795	18.2
1600	1.560	12.5	1.755	16.5
1800	1.556	12.4	1.735	15.5
2000	1.550	12.1	1.675	13.3
2200	1.544	12.1	1.660	11.9

Table III

Additions (5-cc. Increments) of 10% Solution of Magnesium Sulfate to 3000 cc. of Ground Coat

Total cc. added	Sp. gr.	Flow	Hydrometer reading	Pick-up (gm./sq. ft.)
		Feburary 24, 1941		
0	1.559	12.4	1.730	11.1
5	1.559	12.8	1.770	15.9
10	1.559	13.0	1.805	21.0
15	1.559	13.0	1.915	25.5
20	1.559	13.0	1.945	31.2
25	1.559	13.1	2.000	34.8

Table IV

Additions of 10% Solution of Sodium Nitrite to 3000 cc. of Ground Coat

Added cc.	Total cc. present	Sp. gr.	Flow	Hydrometer reading	Pick-up (gm./sq. ft.)
0	0	1.565	12.7	1.670	9.6
25	25	1.560	12.7	1.700	12.6
25	50	1.556	12.8	1.735	15.3
25	75	1.552	12.7	1.750	17.4
50	125	1.543	12.6	1.750	18.6
50	175	1.532	12.6	1.745	18.6
50	225	1.524	12.4	1.700	17.4
50	275	1.516	12.3	1.680	17.4

* Presented at the Forty-Third Annual Meeting, The American Ceramic Society, Baltimore, Md., April 1, 1941 (Enamel Division). Received April 2, 1941; revised copy received September 29, 1941.

[1] J. E. Rosenberg and W. E. Naylor, "Method and Apparatus for Studying the Physical Properties of Viscous Liquids." Presented at Forty-Second Annual Meeting, The American Ceramic Society, Toronto, Canada, April, 1940 (not published).

TABLE V

ADDITIONS (5-CC. INCREMENTS) OF 10% SOLUTION OF HYDROCHLORIC ACID TO 3000 CC. OF GROUND COAT

Total cc. added	Sp. gr.	Flow	Hydrometer reading	Pick-up (gm./sq. ft.)
0	1.566	12.8	1.705	11.7
5	1.566	12.7	1.760	15.9
10	1.566	12.7	1.830	20.1
15	1.566	13.2	1.940	22.8
20	1.566	13.4	1.990	24.0

TABLE VI

ADDITIONS OF 10% SOLUTION OF HYDROCHLORIC ACID TO 3000 CC. OF GROUND COAT

Added cc.	Total cc. present	Set reduced with sodium pyrophosphate Sp. gr.	Flow	Hydrometer reading	Pick-up (gm./sq. ft.)
0	0	1.627	12.6	1.810	12.6
5	5	1.627	12.7	1.915	16.8
1	6	1.627	13.8	1.930	21.9
1	7	1.627	13.8	1.970	24.3
1	8	1.627	13.8	1.995	25.2

TABLE VII

ADDITIONS (5-CC. INCREMENTS) OF 10% SOLUTION OF MAGNESIUM SULFATE TO 3000 CC. OF GROUND COAT

Total cc. added	Set reduced with sodium pyrophosphate Sp. gr.	Flow	Hydrometer reading	Pick-up (gm./sq. ft.)
0	1.621	13.2	1.815	14.4
5	1.621	13.4	1.920	21.3
10	1.623	13.8	2.015	26.1
Set reduced with sodium pyrophosphate	1.624	13.2	1.785	13.5
5	1.623	13.2	1.855	17.4
10	1.623	13.6	1.950	22.5
15	1.623	13.8	2.005	30.9

TABLE VIII

ADDITIONS (5-CC. INCREMENTS) OF 10% SOLUTION OF POTASSIUM CARBONATE TO 3000 CC. OF GROUND COAT

Total cc. added	Set reduced with sodium pyrophosphate Sp. gr.	Flow	Hydrometer reading	Pick-p. (gm./sq ft.)
0	1.620	13.1	1.785	14.1
5	1.620	13.0	1.850	15.9
10	1.620	13.1	1.860	18.3
15	1.620	13.2	1.905	20.4
20	1.620	13.2	1.935	21.9
25	1.620	13.2	1.940	22.8
30	1.621	13.2	1.955	23.7
35	1.621	13.2	1.970	25.5
40	1.621	13.2	1.965	25.8
45	1.621	13.2	1.960	25.2
50	1.621	13.2	1.940	24.6
55	1.621	13.2	1.920	22.8
60	1.621	13.2	1.855	19.5
65	1.622	13.2	1.820	16.2
70	1.622	13.2	1.795	15.9
75	1.622	13.0	1.770	14.1
80	1.622	13.0	1.775	12.9
85	1.622	13.0	1.770	12.9
90	1.623	13.0	1.780	12.3

TABLE IX

ADDITIONS OF 10% SOLUTION OF SODIUM CARBONATE TO 3000 CC. OF GROUND COAT

Added cc.	Total cc. present	Sp. gr.	Flow	Hydrometer reading	Pick-up (gm./sq. ft.)
0	0	1.602	13.2	1.985	31.8
15	15	1.601	13.2	1.965	31.2
15	30	1.600	13.2	1.945	30.0
20	50	1.599	13.1	1.880	25.8
25	75	1.595	12.8	1.730	14.4
25	100	1.591	12.6	1.680	10.5

drometer reading approaches the value obtained with a pycnometer.

The mobility was determined by timing the rate of flow for 100 cc. of slip from a 200-cc. flow tube.

The hydrometer reading was determined by placing a 1.50 to 2.00 hydrometer in the slip in a 1000-cc. graduate cylinder, $2^3/_8$ in. in diameter. The size of the cylinder is important; a cylinder of smaller diameter would lead to errors because its walls would be too close to the hydrometer and would cause a drag. The method of placing the hydrometer into the slip is also important; the velocity with which it drops and the degree of immersion before releasing it greatly affect the distance that it will sink. To standardize these factors, the hydrometer was always immersed to a point just where the bulb and stem join and then was carefully released. In most hydrometers, the paper scale extends exactly to this point and gives a convenient starting point. Successive readings checked very closely with this method.

Pick-up was determined by using an ordinary, ground-coated weigh sheet (1 ft. square) with a hole in one corner. The same dipping motions were used in each case, and the sheet was hung vertically to drain to one corner. The edges were not wiped, but the drop at the tip of the sheet was removed. The pick-up is expressed in grams per square foot of dry weight per one side.

III. Interpretation of Results

The data show definitely that the pick-up and hydrometer reading are closely related, whereas the specific gravity and mobility have little or no bearing on the set. It is possible to establish a mathematical relationship between the hydrometer reading and the pick-up value of the enamel in any one set of data, but this same relationship will not hold true for another set of data. If the frit, clay, or electrolyte is changed, then the hydrometer reading will change for a given pick-up. If additional data are obtained, however, it becomes obvious that the hydrometer reading changes as the pick-up value changes. The specific gravity may be a function of the hydrometer reading, but attempts to bring the specific gravity value into the equation were unsuccessful.

In its present state of development, the hydrometer method is hardly a shop method of determining set. Additional data, however, may reveal other factors, and a mathematical relationship may be determined later.

THE O. HOMMEL COMPANY
PITTSBURGH, PENNSYLVANIA

DECREPITUDE OF OLD BOTTLES: AGING, WEATHERING, AND SOLARIZATION COMPARED WITH USE AND ABUSE *

By L. G. Ghering and F. W. Preston

Abstract

The users of bottles often say that old bottles are stronger than new ones. This is untrue because (1) any greater breakage on the first filling can be attributed to abnormally weak bottles or bottles cracked during shipment; the survivors may give less breakage on the second and third fillings, but the strength of the individual bottle has not actually increased; and (2) the statement is based on the faulty assumption that bottles are not weakened by use.

Experimental tests on fruit jars *in the absence of use* do not show a decrease in the thermal-shock strength after seven years of aging plus three years of weathering by temperature changes, rain, snow, and sunshine. Neither does weathering for three years nor solarization in the direct rays of the July and August sun produce any decrease in the internal pressure strength of bottles.

Mechanical strength tests, fracture diagnoses, and statistical surveys of the performance of bottles *in service*, however, show that the strength of glass containers deteriorates because of mechanical wear, use, and abuse.

I. Introduction

Six or eight years ago, this laboratory was informed by firms engaged in bottling carbonated beverages that old bottles were stronger than new. A consignment of new bottles commonly included some that were weak which broke early in their careers and usually on the first filling, and there remained behind a selected quality of the stronger bottles. Further elimination occurred in subsequent history, and by a process of natural selection ultimately only the strongest bottles remained. This argument sounds logical, but it was claimed that actual hydrostatic-pressure tests had proved this theory to be true.

The pressure tests, unfortunately, had been made at a time when the conditions for accurate testing were unknown, when primitive test apparatus was used, and when a great deal of the "personal equation" was involved. The present writers, moreover, have never been convinced of the validity of these statements, which raises the question of the "logic" contained in the first paragraph.

Bottles used for carbonated beverages are usually so strong when they are first made that there is no reason why any of them should break on the first filling, that is, there is usually a great "factor of safety," and if the bottle breaks, something illogical has already occurred.

It was customary about ten years ago for a manufacturer of bottles to guarantee that not more than 2% would break on the first filling. In one case, this offer proved to be a sort of bonus given to the client because, although the bottles did not break, the customer put in the claim for more bottles anyway. Sometimes this claim involved a substantial number of bottles, and because broken glass was just broken glass and either party could diagnose anything as to the cause of the trouble, the manufacturer and purchaser haggled out a bargain in settlement. Under these conditions, the purchaser could claim to his own advantage that the manufacturer was not making good bottles and that the old bottles were the strongest.

The failure of the logic stated in the first paragraph arises from an implicit assumption that bottles cannot be weakened in use, that is, they can only be broken entirely or left perfect as if new. This is far from true. It is true that careful use does not weaken a bottle, but careful use is not the lot of bottles. Abuse is the rule. This abuse, namely, battering and scratching and chipping, greatly reduces the strength of the bottle, so that in many bottling plants, there are bottles in all states of decrepitude from the brand new to the "all-but-broken."

Until the development of precision testing machinery within the last few years, it was practically impossible to get adequate evidence of how the deterioration took place. The literature contained but little information on the effect of aging and weathering, and some users continued to deny that any deterioration occurred even through use and abuse.

A great deal more information is available now. This has arisen in three principal ways, namely, (1) the means of testing the strength with precision are available; (2) fractures may be diagnosed to show that there has been preliminary weakening and its cause; and (3) statistical methods, applied in carbonating plants to the actual breakage encountered, have proved the existence and even the seriousness of this deterioration.

It is now known that the storage of bottles for years at the point of manufacture rarely produces any measurable diminution of strength, that solarization for months in intense sunlight produces no measurable decline in strength, and that weathering in the open for years, exposed to sun, snow, rain, and wind, produces no measurable decrease of strength. It is also true that normal use and abuse in bottling plants does produce a continuous decline of strength. In Theodore Roosevelt's words, the bottle does not *rust* out; it *wears* out.

Some of the evidence that bottles deteriorate only

* Received July 26, 1941.

through mechanical wear and abuse and not by aging is given in the experimental results that follow.

II. Experimental Results of Weathering Tests on Glass Jars

The household fruit jars used in the weathering tests are described in Table I; about one-half gross of each type was available.

TABLE I

JARS AVAILABLE FOR TESTS

	Type	Date of manufacture
(1)	Quart, square, glass top	1931
(2)	" " " "	1937
(3)	Quart, square, screw top	1934
(4)	" " " "	1937
(5)	Half pint, square, screw top	1936

The bottles were received from the manufacturer in January, 1938; before shipment, they were stored in the manufacturer's warehouse in sealed cardboard cartons with the lids on the jars. Because these cartons tend to prevent condensation of moisture on the glass, only aging (and no weathering) of the jars was considered to have taken place in the warehouse storage.

The degree of annealing of the various lots was the same, that is, temper 2 to temper 4. All were reasonably free from cord and had average commercial distribution, although the 1937 jars were somewhat better than the older ones.

In January, 1938, 36 of each of the five types of jars were given a thermal-shock test, which is the most practical mechanical-strength test to apply to a fruit jar. The thermal-shock test was carried out on the Preston automatic thermal-shock apparatus[1] and conformed to the A.S.T.M. thermal-shock test.[2] The test was started at 80°F. differential and then repeated progressively at 5°F. higher differentials in order to obtain both the initial and 50% breakage thermal-shock differentials.

The other 36 jars of each of the five types were then subjected to a weathering treatment, which consisted in taking them outside the building, removing the caps, and laying them on their sides on the ground so that they were exposed to temperature changes, rain, snow, and sunshine. Under such conditions, moisture alternately collected on and evaporated from both the inside and outside surfaces of the glass. The jars were allowed to lie in this position unmolested for three years, one half of the time shaded in a slightly wooded section and the other half entirely exposed to the direct rays of the sun, the change in position being made after one and one-half years. The weathering treatment, therefore, included some solarization during the summer months. In January, 1941, the weathered jars were then given the same thermal-shock test which the non-weathered jars received in January, 1938, and the results are shown in Table II.

[1] F. W. Preston, "Bottle Breakage, Causes and Types of Fractures," *Bull. Amer. Ceram. Soc.*, **18** [2] 35–60 (1939).

[2] Tentative Method of Thermal-Shock Test on Glass Containers, A.S.T.M. Designation C149–40T, issued 1939; revised August 28, 1940.

III. Discussion of Results on Weathering Tests

The changes in the initial breakage of the five different lots produced by three years of weathering are 0, 0, −10, −5, and +8, respectively. The changes in the 50% breakage were +8, +2, −2, +9, +2, respectively. These changes are within the experimental errors on 36 jar samples. Three years of weathering, therefore, would produce no appreciable change in the thermal-shock strength of glass fruit jars.

These data are subject to the criticism that each test was made on only 36 jars, whereas the 1940 A.S.T.M. test recommends samples of 100 for a test of this sort. This test was started two years before the A.S.T.M. specification was formulated, and it is the only available data on the subject; it is submitted here for what it is worth in preference to waiting several years in order to carry out a new experiment with samples of 100 or more.

IV. Effect of Aging During Warehouse Storage

The relatively recent A.S.T.M. strength tests used in the laboratory tests, unfortunately, were not made at the time that the 1931, 1934, and 1936 jars were manufactured, and, therefore, there are no direct experimental data on the effect on strength of warehouse aging in cartons, which would be seven years of aging in the case of the 1931 jars. The tests made in this laboratory in 1938 show that the not-weathered 1937 glass-top jars were slightly stronger than the 1931 jars and that the 1937 screw-cap type top were stronger than those made in 1934.

These differences, however, are accounted for by the fact that the 1937 jars were less cordy and had somewhat better distribution than the older jars. The lower strength of the 1931 and 1934 jars as compared with the greater strength (persisting for three years) of the 1937 jars therefore should not be interpreted as a deterioration of the older jars due to the aging in the sealed cartons (six years for the glass top jars and three years for the screw top).

V. Experimental Results on Effect of Solarization and Weathering

A group of 450 recently manufactured $10^1/_2$-oz. weight, 12-oz. capacity, flint steinie beer bottles were available for this experiment. These were taken con-

TABLE II

RESULTS OF THERMAL-SHOCK TESTS

Type	Vintage	Thermal-shock breakage (°F.) Initial	50%
Quart, square (glass top)	1931*	85	102
	1931†	85	110
Quart, square (glass top)	1937*	90	119
	1937†	90	121
Quart, square (screw cap)	1934*	100	105
	1934†	90	103
Quart, square (screw cap)	1937*	95	113
	1937†	90	122
Half pint, square (screw cap)	1936*	96‡	124
	1936†	104‡	126

* Not weathered.
† Weathered.
‡ Differential progressively increased 4° instead of 5°F

secutively from the lehr without glass-to-glass contact and packed in individual cell cartons. In the solarization test, all were taken outside and set upright on cardboard exposed to the direct rays of the midsummer sun. Group A, consisting of 150 bottles, was immediately brought back into the laboratory and tested; group B was allowed to solarize and weather in the sun for two months (July and August) and then was tested in the same manner as group A; group C, consisting of 150 bottles, was placed in a shaded area and allowed to weather for three years.

The A.S.T.M. Hydrostatic Pressure Test[3] was used, starting at 250 lb. per sq. in. internal pressure and increasing 50 lb. per sq. in. at the end of each minute until the bottle burst. The results are given in Table III.

TABLE III

AVERAGE INTERNAL PRESSURE STRENGTH OF SOLARIZED AND WEATHERED BOTTLES

Group	Pressure strength avg. (lb./sq. in.)
A (not solarized)	338 ± 10*
B (solarized and weathered 2 mo.)	357 ± 10*
C (weathered 3 yr.)	317 ± 10*

* Probable error.

Solarization plus weathering over a period of two months as well as weathering for three years produced no significant change in strength inasmuch as the experimental error is somewhat greater than the probable error, which is listed in Table III and is calculated on the assumption that the strength of the bottles in the various groups follows the normal distribution curve.

VI. Effect of Mechanical Wear (Use and Abuse) on Mechanical Strength

It is well known that the strength of glass containers is decreased by mechanical wear, use, and abuse in service. Preston has already given data[4] on Coca Cola bottles obtained by Hunter[5] at this laboratory. It was found that new Coca Cola bottles gave only 4% of breakage at 400 lb. per sq. in. internal pressure, whereas bottles which had been in service from one to ten years gave progressively greater breakage, the breakage being 27% for bottles ten years old. Because this decrease in strength paralleled the visible wear, bruising, and battering inflicted in service, it was concluded that the decrease in strength was due to these mechanical effects rather than to aging or weathering.

Thermal-shock strength tests also made by Hunter showed a similar decrease in the thermal-shock strength of Coca Cola, beer, and ginger ale bottles; here, too, the decrease in strength was proportional to the number of years the bottles had been in service.

By an entirely different method of attack, further information on the effect of the amount of use and abuse on strength has recently been obtained.[6] An analysis of the breakage of milk bottles occurring in the bottling plants showed that most breakage occurred in several stages owing to a series of injuries to the surface of the glass. The magnitude of the final force which broke the bottle, whether impact, internal pressure, or thermal shock, was not so much an indication of the original strength of the bottle as a reflection of its wear and repeated abuses.

An analysis of many broken bottles and a comparison of the number of bottles of a given vintage that broke with the number of that vintage in service revealed that a milk bottle in its fourth year of service was twice as apt to break as one in its first year of service. The actual ratios of percentage in breakage to percentage in use are given in Table IV. Similar data are being obtained on other types of bottles and in a large number of bottling plants.

TABLE IV

RATIO OF BREAKAGE TO USE

Years of service	Per cent in breakage / Per cent in use
First	0.82
Second	0.92
Third	1.41
Fourth	1.67

VII. Mechanical Abuse Plus Weathering

New jars and bottles were used in all of the foregoing weathering experiments; ware that is badly battered and bruised through use has not been subjected to a similar test. There is some evidence, however, that strong chemical agents will extend fissures and cracks that are present in bruised and battered ware and thus accelerate deterioration.[6] The deterioration of used ware that has been allowed to stand several hours in a strong solution of caustic soda, such as in a commercial bottle-washer machine or soaker, at elevated temperatures is an example of chemical attack. Such drastic treatment, however, can hardly be termed weathering.

Any detailed account of the effect of weathering on the mechanical strength of battered and bruised ware will have to await further experimental work.

VIII. Conclusions

The analysis of the performance of bottles *in service* shows clearly that old used bottles are not so strong as new ones. The laboratory tests also show a decrease in strength resulting from a long life in service. On the other hand, aging, weathering, and exposure to sunlight in the absence of mechanical wear, use, and abuse cause no perceptible change in strength. It must be concluded, therefore, that the deterioration of the strength of glass containers in service results primarily from mechanical wear, use, and abuse.

PRESTON LABORATORIES
BUTLER, PENNSYLVANIA

[3] Tentative Method of Hydrostatic Pressure Test on Glass Containers, A.S.T.M. Designation C147–40T; see also footnotes 1 and 2.

[4] F. W. Preston, *loc. cit.*

[5] R. G. Hunter formerly Owens-Illinois delegate with the Preston Laboratories.

[6] J. H. Toulouse, "Problems in Handling Glass Containers for Milk," *Bull. International Assn. of Milk Dealers*, **33** [9] 223–34 (January 6, 1941).

[6] James Bailey, "On Chemical Durability," *Glass Ind.*, **15** [8] 171–73 (1934); *Ceram. Abs.*, **13** [11] 289 (1934).

GLASS-BATCH MIXING*

By Wayne E. Brownell and S. R. Scholes

Abstract

Laboratory methods of mixing, sampling, and analyzing batches are discussed. The idea of segregation of particles by continued mixing is shown to be fallacious. The use of powdered materials to improve the rate and thoroughness of mixing is recommended.

I. Introduction

The importance of good mixing of batch as a prerequisite to the production of homogeneous glass is recognized. The factors responsible for good mixing, however, are not easily determined, nor is it often possible in practice to demonstrate the effectiveness of the method in use. The type of mixer employed, the speed of rotation, the time of mixing, and the physical character of the raw materials enter into the problem. The effectiveness of the mixing operation, furthermore, may be demonstrated by the sampling and analysis of the mixed batch.

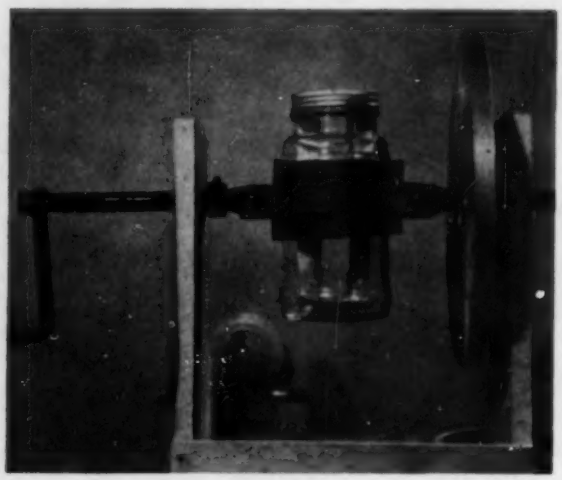

Fig. 1.—Mixer No. 1.

II. Apparatus

Small mixers were built for this work, simulating some of the types in commercial use.

Figure 1 shows the first type of mixer. It is a simple drum turned end-over-end and supplied with removable blades. The capacity of the mixer is about 1400 cc. A standard three-component batch of 550 cc. was used in the experiments.

The second type of mixer, shown in Figs. 2 and 3, is a rotating double cone, equipped with four blades adjusted to draw the material toward the center. It is driven by an electric motor with a reduction gear providing three speeds, and it has a capacity of about 1000 cc.

III. Raw Materials

Sand, soda ash, and precipitated calcium carbonate (whiting) were selected as the principal raw materials to be studied. Sand and soda ash appear in most glass batches. Although whiting is not physically representative of many of the commercial limes, it takes the place of one third more finely granular or powdered material. These three ingredients, furthermore, are quite simply separated for quantitative batch analysis;

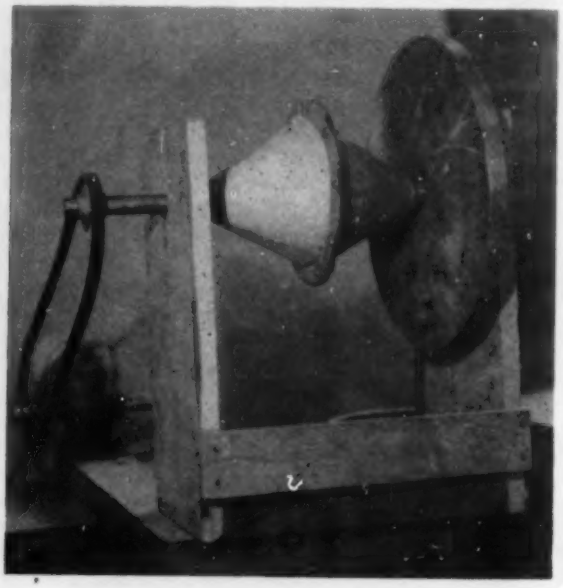

Fig. 2.—Mixer No. 2.

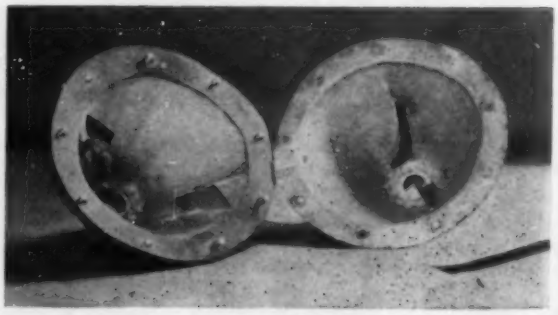

Fig. 3.—Mixer No. 2.

* Presented at the Forty-Third Annual Meeting, Baltimore, Md., April 2, 1941 (Glass Division). Received July 19, 1941.

This paper contains a portion of a bachelor's thesis by W. E. Brownell, New York State College of Ceramics, Alfred, N. Y.

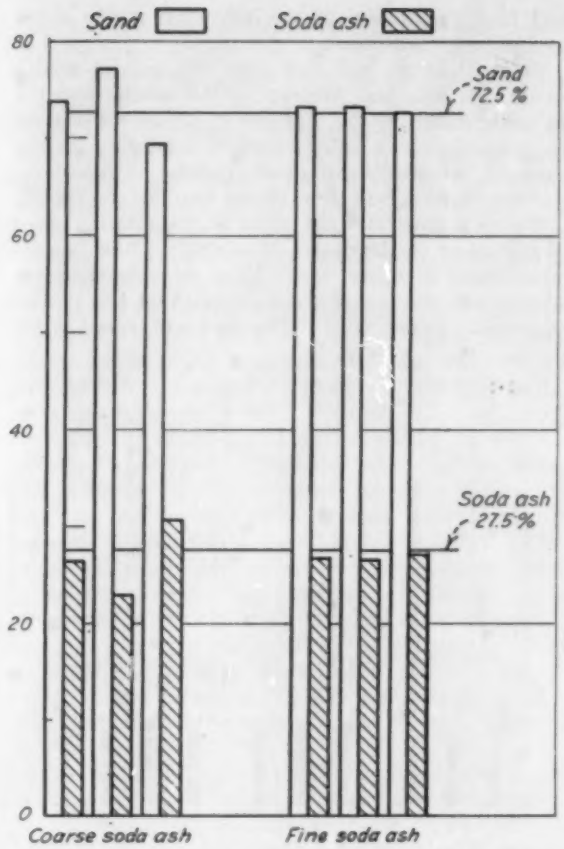

FIG. 4.—Influence of fineness of soda ash on degree of mixing (5 minutes at 20 r.p.m.).

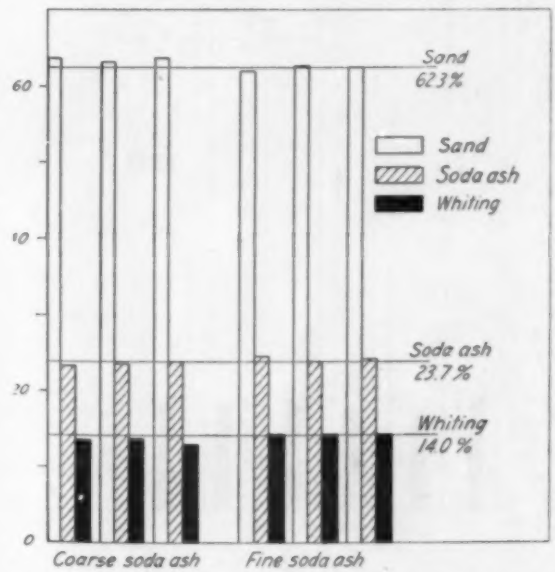

FIG. 5.—Influence of fineness of soda ash on degree of mixing (5 minutes at 30 r.p.m.).

in certain batches, zinc oxide was used to replace whiting.

Screen analysis of the raw materials showed that the sand passed completely through 20-mesh and 62% was retained on a 70-mesh screen. The granular soda ash also passed a 20-mesh screen completely and 40% was retained on 70-mesh. The whiting and zinc oxide were 200-mesh.

IV. Sampling and Analyses

The size of a sample in proportion to the entire batch is a problem. A small sample may not be representative, whereas a large sample offers too much room for the balancing of errors. After a number of trials on samples ranging from 0.5 to 24 gm., a 10-gm. sample from the 550-gm. batch was found to be convenient for the analytical operation and for consistent results.

Samples were lifted by a spoon from several locations in the batch as it was dumped from the mixer. All of each sample was weighed and used for analysis to avoid segregation.

Each weighed sample was treated with boiling water which dissolved only the soda ash. The residue from filtration was dried and weighed with the weight of

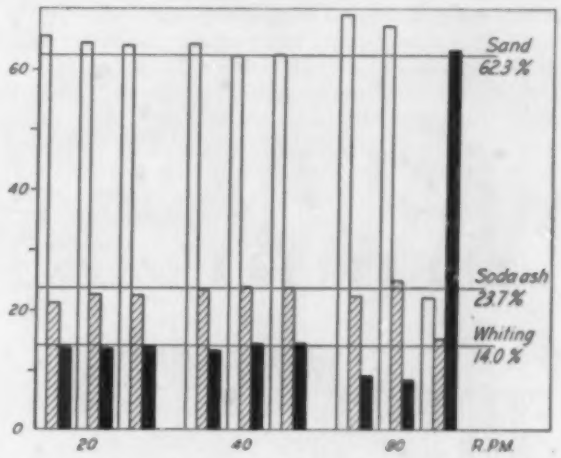

FIG. 6.—Effect of r.p.m. of mixer on degree of mixing (5 minutes mix).

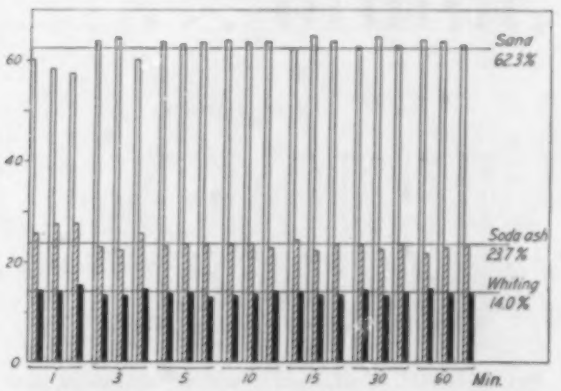

FIG. 7.—Effect of time on degree of mixing (30 r.p.m.).

soda ash given by difference; this residue was treated with dilute hydrochloric acid to dissolve the whiting (or the zinc oxide). The sand was filtered off, dried, and weighed, and the weight of whiting was obtained by difference. The percentage of each constituent was calculated and compared to the original batch composition.

The accuracy of this method was checked by running blank samples containing a known amount of each constituent; the analytical error did not exceed 0.1%.

V. Experimental Results

A large number of batches were mixed under different conditions and analyzed for the comparison of results (see Figs. 4 to 10). Figure 4 shows the effect of the relative fineness of soda ash on the degree of mixing. These batches were mixed for 5 minutes at 20 r.p.m. in mixer No. 1. The fine soda ash used consisted of the ordinary soda ash ground to pass a 200-mesh screen; fine soda ash mixes more quickly and intimately with sand than does the granular form. Throughout the investigation, it was much easier to mix sand and whiting than sand and granular soda ash, which does not agree with preconceived ideas concerning the ease with which two materials of approximately the same screen analysis mix. The difference may be due to the fact that the density of the individual grains of the two materials is different.

Figure 5 shows how fine soda ash aids in mixing sand, soda ash, and whiting. These results were obtained in mixer No. 2. The use of 200-mesh soda ash is undesirable as a batch material because of dust; a material between the 20-mesh granular form and the pulverized form will give better results (see Fig. 5).

Figure 6 illustrates the effect of the rotating speed of the mixer on the degree of mixing. These batches were mixed in mixer No. 1 for 5 minutes using the blades, and the earlier trials showed that this process improved the operation. The 40 r.p.m. speed is the

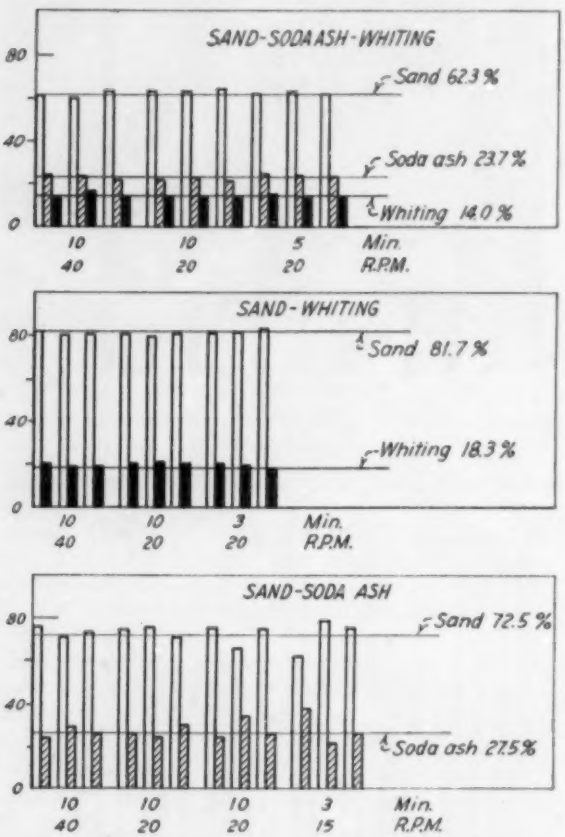

FIG. 8.—Effect of addition of whiting on mixing sand and soda ash.

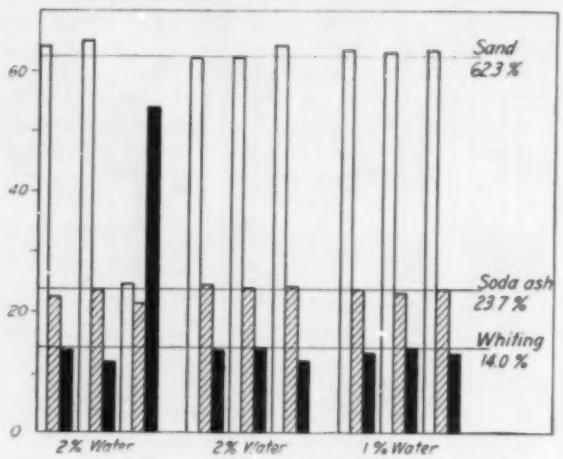

FIG. 9.—Effect of water additions on degree of mixing (30 r.p.m. to 10 minutes).

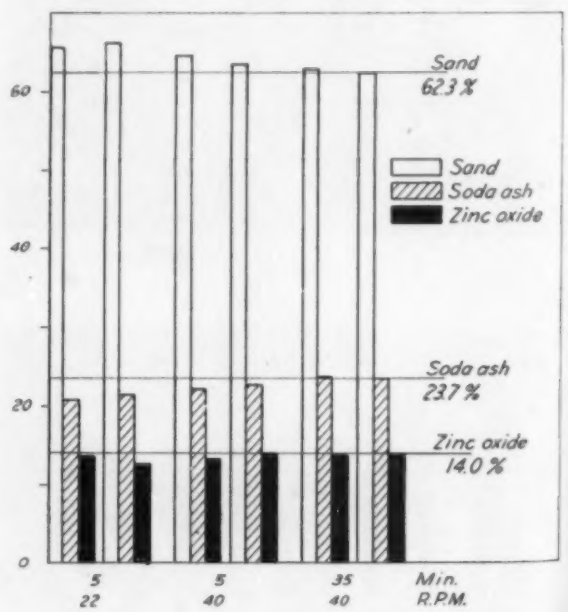

FIG. 10.—Effect of time and r.p.m. on degree of mixing zinc oxide with glass batch.

best for this type of apparatus. The optimum speed for any mixer depends on its size; it must be slower as the size of the mixer increases in order to allow time for the movement of the material.

The effect of time is indicated in Fig. 7. All of these mixes were made in mixer No. 2. At 1 and 3 minutes, mixing was incomplete, but at 5 and 10 minutes the best mixing was obtained. The results were not so good at 15, 30, and 60 minutes, not because of segregation but because more of the material tended to stick to the blades of the mixer.

Figure 8 shows that when whiting is used as a third ingredient it acts as a distributing agent and that better mixing is obtained than when sand and soda ash are the only ingredients. The apparatus used in this case was mixer No. 1.

The effect of the addition of water to the batch is illustrated in Fig. 9. The batch at the left contained 2% of water, which was added after the mixing was started. At the end of 10 minutes, many lumps appeared. Water in the next batch was added to the sand and thoroughly mixed with it before the other constituents were added. In the batch on the right, 1% of water was added to the sand before the rest of the batch was put in. All of these batches were mixed in mixer No. 2 at 30 r.p.m. for 10 minutes. Little advantage is gained by the addition of water, and it may even have a detrimental effect on the degree of mixing.

Zinc oxide is an example of a material with an extremely fine and clinging character which has a tendency to ball during the mixing operation. Several sample batches containing zinc oxide, soda ash, and sand were tested, and the results are shown in Fig. 10. In the batch which was mixed for 35 minutes at 40 r.p.m., the zinc oxide had been mixed with the sand alone for 30 minutes before the soda ash was added for the remaining 5 minutes of rotation.

VI. Summary and Conclusions

(1) The grain size of the materials and the density of individual particles are important considerations affecting batch mixing; granulations finer than 20-mesh are desirable.

(2) The presence of one of the batch ingredients (for example, whiting, limestone, or hydrated lime) in a finely powdered condition promotes good mixing.

(3) Although it is not possible to prevent the agglomeration or balling of certain materials, such as zinc oxide, this condition may be alleviated by prolonged mixing and by preliminary mixing of the troublesome material with sand alone.

(4) The addition of water is detrimental. When water is added, in order to prevent dust, it should be mixed with the sand before the other ingredients are added.

(5) The proper speed for the mixing device is important. Excessive speed may prevent good mixing, whereas a low speed continued for sufficient time will produce good results. The speed, however, should vary with the type and size of the mixture.

(6) The time of mixing is important when a glass batch is mixed. A very short mixing time is sufficient, in general, and further mixing does not improve the homogeneity of the batch. There is no reason, however, to believe that unmixing or segregation can be produced by prolonging the mixing operation. When a material such as zinc oxide is present, however, the mixing time should be prolonged.

Department of Glass Technology
New York State College of Ceramics
Alfred, New York

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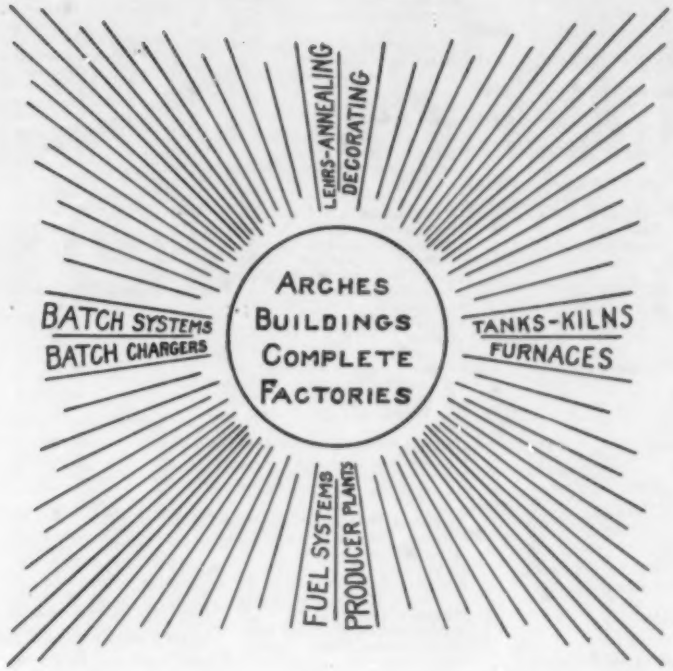

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	Titanium oxide (TiO_2)	1.29
	Ferric oxide (Fe_2O_3)	0.55
	Lime (CaO)	0.00
	Magnesia (MgO)	0.00
	Alkalis (Na_2O,K_2O)	0.00
Mechanical Composition	—20 microns	98.00%
	—10 "	80.98
	— 6 "	70.94
	— 3 "	54.70
	— 1 "	37.74
	— 0.5 "	21.75

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Ceramic Color & Chemical Mfg. Co.
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Lancaster Iron Works, Inc.
F. J. Stokes Machine Company
Grinding Wheels
Carborundum Co. (*Carborundum and Aloxite*)
Norton Co. (*Alundum-Crystolon*)
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Carborundum Co. (*Carbofrax* heat treating)
Corhart Refractories Co.
Norton Co. (*Crystolon*)
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Norton Co.
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Denison Engineering Co.
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Ceramic Color & Chemical Mfg. Co.
Harshaw Chemical Co.
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Iron Oxide
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Harshaw Chemical Co.
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The Vitro Mfg. Co.
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Ceramic Color & Chemical Mfg. Co.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
Maxson, Elwyn L.
Paper Makers Importing Co.
Thomas Alabama Kaolin Co.
United Clay Mines Corp.
The Vitro Mfg. Co.
Kilns, China (Decorating)
Denver Fire Clay Co.
Drakenfeld, B. F., & Co.
Frazier-Simplex, Inc.
The Hommel, O., Co., Inc.
Swindell-Dressler Corp.
Kilns (Electric, Circular, Tunnel)
Swindell-Dressler Corp.
Kiln Furniture (Silicon Carbide, Semi-Silicon Carbide) (Refractory)
Electro Refractories & Alloys Corp.
Louthan Mfg. Co.
Kryolith (see Cryolite)
Pennsylvania Salt Mfg. Co.
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Norton Co.
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Swindell-Dressler Corp.
Lehrs (Electric or Fuel Heated)
Frazier-Simplex, Inc.
Swindell-Dressler Corp.
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Frazier-Simplex, Inc.
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Corhart Refractories Co.
Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
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Norton Co.
The Vitro Mfg. Co.
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Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Foote Mineral Co.
Lithium Minerals
Foote Mineral Co.
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Electro Refractories & Alloys Corp.
Norton Co.
Magnesia (Sintered, Calcined)
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Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
The Vitro Mfg. Co.
Magnesite Calcined
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The Hommel, O., Co., Inc.
Magnesium Carbonate
Ceramic Color & Chemical Mfg. Co.
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Harshaw Chemical Co.
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Manganese
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Drakenfeld, B. F., & Co.
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Harshaw Chemical Co.
The Hommel, O., Co., Inc.
The Vitro Mfg. Co.
Manganese Dioxide
Ceramic Color & Chemical Mfg. Co.
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Foote Mineral Co.
Manganese (Oxide)
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Drakenfeld, B. F., & Co.
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Foote Mineral Co.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
The Vitro Mfg. Co.
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Remember . . . .

Metal & Thermit has an entire plant devoted to the production of Oxide of Antimony for ceramic purposes. Part of the output of this plant is used in the manufacture of our Sodium Antimonate, the remainder is available to producers of ceramic products. And, M & T Oxide of Antimony is made with the same care, has all the uniform high quality that have so long distinguished M & T Tin Oxide and M & T Sodium Antimonate.

METAL & THERMIT CORPORATION

Ceramic Department

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